Attorney Client Privileged
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Columbia/Snake Rivers Temperature TMDL
[Comments in red by Don A. Essig, IDEQ, 8/13/02]

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Table 6-1: Summary of the Columbia/Snake River TMDL, showing gross allocations for each river reach and individual wasteload or load allocation for each facility in every river reach.

Executive Summary

Description of Waterbody, Pollutant of Concern, and Pollutant Sources

This Total Maximum Daily Load (TMDL) addresses water temperature in the mainstem segments of the Columbia River from the Canadian Border (River Mile 745) to the Pacific Ocean and the Snake River from its confluence with the Salmon River (River Mile 188) to its confluence with the Columbia River. The States of Oregon and Washington and the U.S. Environmental Protection Agency (EPA) have listed multiple segments of both mainstem reaches on their federal Clean Water Act (CWA) 303(d) lists due to water temperatures that exceed state water quality standards (WQS). The entire reaches of both rivers are considered impaired for water temperature. EPA is establishing this TMDL for waters within the States of Oregon and Washington and within the Reservations of the Confederated Tribes of the Colville Reservation and the Spokane Tribe of Indians. The Idaho Department of Environmental Quality is simultaneously issuing the TMDL for waters within the jurisdiction of the State of Idaho.

Water temperature can be elevated above natural conditions by a number of human activities. The sources of elevated temperatures in the Columbia and Snake Rivers are point sources, nonpoint sources, dams and ~~climate change~~global warming. Point sources discharge thermal energy directly to the river. Nonpoint sources such as agricultural run off discharge to the rivers primarily via irrigation canals and tributaries. ~~Dams~~ Impoundments alter river temperature by changing the flow regime, stream geometry, current velocity and flood plain interactions of the river. ~~Climate change, or g~~Global warming, increases the heat load to the river from meteorological conditions.

The effects of point sources and tributaries (nonpoint sources) on cross sectional average water temperatures in the main stems are for the most part quite small. The point sources can cause temperature plumes in the near-field but they do not result in measurable increases to the cross-sectional average temperature of the main stems. The ~~dams~~impoundments, however, do cause measurable changes in the cross-sectional average temperature of the main stems. Collectively ~~T~~they increase the cross-sectional average temperature and ~~they~~ extend the period of time during which the water temperature exceeds numeric temperature criteria. The effects of global warming have not been quantified for the Columbia and Snake Rivers, but analysis of the Fraser River indicates that global warming likely contributes to changes in the temperature regime of the rivers that could account for nearly half of the observed increase in Columbia River temperatures since the early 1930's.

Commented [DE2]: Page: 1
Not all climate change is unnatural, the term global warming is specific to the human caused portion of climate change and thus, I believe, preferred here. I also think the word impoundment is preferably to dam as it is the former that really alters water T, hence the difference among impoundments in their effect.

Description of the Applicable Water Quality Standards and Numeric Targets

The WQS for temperature on the Columbia and Snake Rivers are quite complex. The three states and one tribe with EPA-approved standards have adopted a variety of numeric and narrative criteria for temperature in the segments of the Columbia/Snake mainstems within their jurisdictions. A common component in all of the standards is a provision to account for times when natural water temperatures in the rivers exceed numeric water quality criteria. Generally, when this occurs, the standards allow small incremental increases to the natural temperatures. Washington WQS, which apply to all of the TMDL project area except the upper 12 miles of the Snake River reach, also restrict incremental increases in temperature when the natural temperature is below numeric criteria. The TMDL is based on the most stringent standards that apply on the rivers reach by reach. Table S-1 summarizes the WQS standards that are the basis for this TMDL. DM = Daily Maximum, 7DADM = 7-day Average of Daily Maximums

Table S-1: Summary of Water Quality Standards that Apply to the Columbia and Snake Rivers

Columbia River Reach	**Criterion [need to specify metric, e.g Daily Max or 7DADM**	**Natural Temp < Criterion**	**Natural Temp > Criterion**
Canadian Border to Grand Coulee Dam	16 EC DM	Natural + 23/(T+5)	Natural + 0.3 EC
Grand Coulee Dam to Chief Joseph Dam	16 EC DM	Natural + 23/(T+5)	Natural + 0.3 EC
Chief Joseph Dam to Priest Rapids Dam	18 EC DM	Natural + 28/(T+7)	Natural + 0.3 EC
Priest Rapids Dam to Oregon Border	20 EC DM	Natural + 34/(T+9)	Natural + 0.3 EC
Oregon Border to mouth	20 EC 7DADM	Natural + 1.1 EC	Natural + 0.14EC
Snake River Reach	**Criterion**	**Natural Temp < Criterion**	**Natural Temp > Criterion**

Salmon River to OR/WA Border	12.8/17.8 EC Idaho also has a spawning T of 9°C DA/13°C DM that apply and are more stringent than Oregon's	Up to Criterion	Natural + 0.14 EC
OR/WA Border to ID/WA Border	20 EC DM	Natural + 1.1 EC	Natural + 0.3 EC
ID/WA Border to Mouth	20 EC DM	Natural + 34/(T+9)	Natural + 0.3 EC

t = the maximum permissible temperature increase measured at a mixing zone boundary
T = the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.

Development of the target temperatures for the TMDL depends on an understanding of natural temperature. A mathematical water quality model was used to simulate temperature conditions in the mainstems of the Columbia and Snake Rivers in the absence of ~~human activity~~dams and point sources in the mainstems. The simulations utilize existing flow and temperature in the tributaries and at the TMDL boundaries. These simulated temperatures are not necessarily natural because they do not account for climate change or altered water temperature and flow regimes outside the TMDL project area. To maintain the distinction from purely natural temperatures, they are referred to as site potential temperatures. This TMDL is based on the site potential temperatures; the temperatures that are estimated to occur in the absence of human activity in the mainstems.

Commented [DE3]: Page: 1
As point of fact dams and point sources are the only human activities that have been factored out via modeling, so lets not imply otherwise.

The site potential temperatures in the mainstems vary considerably throughout the year, from year to year, and longitudinally along the rivers. To account for the temporal variation, the site potential temperatures are simulated using a thirty year data record and the target temperatures for the TMDL are expressed as thirty year mean temperatures for every day of the year. To account for the spatial variation, the rivers are divided into 19 longitudinal reaches with a TMDL Target Site at the down river end of each reach. [nice summary]

The mathematical model has been used to evaluate cumulative impacts of upstream temperature impacts on downstream segments of the TMDL. This analysis indicates that elevating temperatures of upstream segments to the degree allowed under the WQS (Table S-1) would result in exceedances of WQS in downstream segments. As a result, the target temperatures in the lower reach of the Columbia River drive the upstream allocations for this TMDL. Therefore, the target temperatures of each reach above the Oregon/Washington Border are lower than those ~~prescribed~~ allowed by Table S-1. The targets at each upper reach are lowered enough to ensure that the target temperature in the ~~lower~~ downstream reach are achieved. Figure S-1 illustrates the existing temperature and the TMDL target temperature at the John Day target site. [as an example? Why John Day?]

Loading Capacity

The loading capacity is expressed as temperature rather than as thermal load. The regulations governing TMDL development provide for the expression of TMDLs as "either mass per time, toxicity, or other appropriate measure" (40CFR130.2(h)). Temperature is an appropriate measure in this TMDL because dams play a major role in altering the temperature regime of the river but they do not discharge water bearing a thermal load to the river. Dams alter the temperature regime of the river by altering the stream geometry and current velocity upstream of the dam. Expressing the loading capacity and allocations as temperatures addresses a potential concern that dam operators could choose to alter flow in the river to achieve thermal load targets without improving temperature. [Another reason to focusing on delta T, or incremental load added (if you translate delta T to a load). Can't reduce your increase in T, or added load, by just turning down the flow.]

Pollutant Allocations (see Table S-2)

The load available for allocation is the temperature increment over the natural or site potential temperature allowed under the WQS. [This sounds like assimilative capacity aka load capacity, so belongs up under previous subhead] This temperature increment is almost entirely consumed by the allocations to the point sources as wasteload allocations (WLA). [My reading of the allocation tables is that only about half the capacity is consumed by point sources, the remainder is a reserve] In the WLA, the load each point source can discharge to the river is expressed as megawatts (MW). [megawatt-hours (or day) be a more proper load unit, i.e. a quantity of heat energy, rather than MW, which is just a rate of heat energy release, any way MW seems awkward] There are 106 Point Sources in this TMDL. All but 12 of the point sources have an insignificant effect on mainstem temperatures (defined for the purpose of this TMDL as less than 0.014 EC). These 94 smaller point sources are included in group allocations for each reach. The 12 larger point source dischargers receive individual allocations.

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Since the Site Potential simulations utilize existing tributary temperatures, none of the temperature increment is allocated to tributaries. All tributaries are allocated their existing loads. Since the temperature increment remaining after allocation to the point sources is minuscule, the temperature increase allocated to the 15 dams is zero.

Margin of Safety

A small portion of the available temperature increases can be allocated to the margin of safety. The RBM 10 model was used to determine the temperature increases available after allocation to the point sources. The analysis indicates that water temperature at each dam site can only be increased by approximately 0.01 EC in addition to the increase caused by point sources upstream of the dam site. This 0.01 EC is meaningless in the operation of the dams but could be used as an element of the margin of safety or the future growth reserves.

There have also been implicit margins of safety built into the TMDL. For point sources the WLA is based on worst case discharges. Further, the wasteload allocation for point sources does not vary with flow. It achieves water quality standards at the 7Q10 low flow, thereby providing a margin of safety when flows are greater than the 7Q10. For dams, the use of daily average temperatures (as opposed to maximum temperatures only) is a conservative application of the WQS provisions regarding natural temperature conditions [This will need to be explained better as it is counterintuitive, not generally the case. The key appears to be the fact that diurnal ranges have been dampened in the regulated Columbia and Lower Snake Rivers].

Seasonal Variation

Temperature varies seasonally along the rivers. Generally, both rivers exceed water quality criteria during the summer along their entire lengths. Since the WQS are tied to natural conditions, they vary throughout the year, changing with the seasons. [I don't think this is a valid interpretation of the OR and ID WQS. My read is that they vary only when thermal potential is above the criterion threshold] Seasonal variation was incorporated into the temperature ~~targets by using 30-year simulations from the RBM 10 water temperature model. The~~ TMDL by establish~~es~~ing targets for each day of the year to account for changes in the ~~water quality standard~~site potential throughout the year.

Future Growth

A small portion of the available temperature increases can be allocated to future growth. The RBM 10 model was used to determine the remaining temperature increases available after allocation to the point sources. The analysis indicates that water temperature at each dam site can only be increased by approximately 0.01 EC in addition to the increase caused by point sources upstream of the dam site. This 0.01 EC is meaningless in the operation of the dams but could be used as an element of the margin of safety or the future growth reserves.

Monitoring Plan

Long term, system wide effectiveness of TMDL implementation activities can be assessed by monitoring mainstem river temperatures at the target sites. Over the long term, if implementation is adequate, the daily mean temperatures at the ~~target~~ compliance site should equal the ~~loading capacities~~30-year average target temperature at those sites. Individual years may exceed those ~~loading capacities~~temperatures because of ~~the~~ natural variations ~~in temperature~~.

Short term monitoring for compliance with WLAs will be accomplished through effluent monitoring by the point sources. For individual dams, one option for short term monitoring is to evaluate the temperature difference between successive dams. The TMDL includes curves showing the temperature differences for existing conditions and for the conditions of the implemented TMDL. Effectiveness of TMDL implementation within individual impoundments can be determined by comparison of actual temperature differences between dams to the TMDL curves.

Implementation Plans

Implementation plans will be developed by the States.

Public Participation

Extensive public involvement activities, organized by the inter-agency TMDL Coordination Team have occurred for this TMDL over the past two years. Activities have included websites, fact sheets, coordination meeting, individual meetings with interested groups, nine public workshops and numerous conference presentations.

[I couldn't get page numbers to show up on the printed copy of the following table]

Table S-2: Summary of the Columbia/Snake River TMDL, showing gross allocations for each river reach and individual wasteload or load allocation for each facility in every reach.

River Reach / Facility	Temperature Increase Allowed Within Each Reach	Wasteload Allocation	Load Allocation	MoS or Future Growth
International Border to Grand Coulee	.01005 EC	0.00005 EC	0.0 EC	.01 EC
Group		1.37 MW		
Grand Coulee Dam			0.0 EC	
Grand Coulee to Chief Joseph	.01005 EC	0.00005 EC	0.0 EC	.01 EC
Group		5.52 MW		
Chief Joseph Dam			0.0 EC	
Chief Joseph to Wells	.01009 EC	0.00009 EC	0.0 EC	.01 EC
Group		3.79 MW		
Wells Dam			0.0 EC	
Wells to Rocky Reach	.0102 EC EC	0.0002 EC	0.0 EC	.01 EC
Group		8.02 MW		
Rocky Reach Dam			0.0 EC	
Rocky Reach to Rock Island	0.011 EC	0.001 EC	0.0 EC	.01 EC
Group		70.81 MW		
Rock Island Dam			0.0 EC	
Rock Island to Wanapum	.01001 EC	0.00001 EC	0.0 EC	.01 EC
Group		0.45 MW		
Wanapum Dam			0.0 EC	

Wanapum to Priest Rapids	**.01 EC**	**0.0 EC**	**0.0 EC**	**.01 EC**
Priest Rapids Dam			**0.0** EC	
Priest Rapids to McNary	**.037 EC**	**0.027 EC**	**0.0 EC**	**.01 EC**
Group		**224.14 MW**		
Agrium Bowles Road		**405.82 MW**		
Agrium Game Farm Road		**484.69 MW**		
Boise Cascade Walulla		**234.90 MW**		
McNary Dam			**0.0** EC	
McNary to John Day	**.0105 EC**	**0.0005 EC**	**0.0 EC**	**.01 EC**
Group		**39.81 MW**		
John Day Dam			**0.0** EC	
John Day to The Dalles	**.010009 EC**	**0.000009 EC**	**0.0 EC**	**.01 EC**
Group		**0.72 MW**		
The Dalles Dam			**0.0** EC	
The Dalles to Bonneville	**.014 EC**	**0.004 EC**	**0.0 EC**	**.01 EC**
Group		**24.36 MW**		
SDS Lumber		**160.32**		
Bonneville Dam			**0.0** EC	
Bonneville to River Mile 119	**.006 EC**	**.006EC**	**0.0 EC**	**0.0 EC**
Group		**36.36213 MW**		
Georgia Pacific		**313.21 MW**		

River Mile 119 to River Mile 63	0.05 EC	.05 EC	0.0 EC	0.0 EC
Group		1219.995 MW		
Boise/ St.Helens		219.56 MW		
Coastal St. Helens		365.09 MW		
PGE Trojan		511.15 MW		
Longview Fiber		540.99 MW		
Weyerhouser Longview		398.63 MW		
River Mile 63 to River Mile 42	0.006 EC	0.006 EC	0.0 EC	0.0 EC
Group		31.881 MW		
GP Wauna		301.71 MW		
River Mile 42 to River Mile 0	0.0002 EC	0.0002 EC	0.0 EC	0.0 EC
Group		32.569 MW		
Salmon River to Lower Granite	0.0434 E	0.0334 EC	0.0 EC	0.01 EC
Group		10.28 MW		
Potlatch		298.76 MW		
Lower Granite Dam			0.0 EC	
Lower Granite to Little Goose	0.01000009 EC	0.00000009 EC	0.00 EC	0.01 EC
Little Goose Dam			0.0 EC	
Little Goose to Lower Monumental	0.0101 EC	0.0001 EC	0.0 EC	0.01 EC
Group		1.38 MW		
Lower Monumental Dam			0.0 EC	

Lower Monumental to Ice Harbor	**0.0100001 EC**	**0.0000001 EC**	**0.0 EC**	**0.01 EC**
Ice Harbor Dam			**0.0 EC**	

1.0 Introduction

1.1 Scope of this TMDL

The scope of this TMDL is water temperature in the main stem segments of the Columbia River from the Canadian Border (River Mile 745) to the Pacific Ocean and the Snake River from its confluence with the Salmon River (River Mile 188) to its confluence with the Columbia River (see Figure 1-1). Table 1-1 summarizes the portions of the two rivers listed as impaired for temperature pursuant to Section 303(d) of the Clean Water Act. EPA listed the Snake River from the Salmon River to the Washington/Idaho Border on the Idaho 1998 Section 303(d) (EPA, 2001). Oregon included the entire Oregon portions of the Snake and Columbia rivers on its 1998 Section 303(d) list (Oregon DEQ, 1998). Washington included 26 different segments of the two rivers on its 1998 Section 303 list (Washington DOE, 1998). In a letter dated September 4, 2001, Washington clarified that "...much or all of the mainstem Columbia and Snake Rivers violate water quality standards for temperature..." and that the entire lengths of the Columbia and Snake rivers should be addressed in the temperature TMDL (Washington DOE, 2001). This TMDL addresses dams, point sources and non-point sources of thermal loading to the main stems themselves. There are 15 dams, as well as 106 point sources regulated by National Pollutant Discharge Elimination System (NPDES) permits, on the two main stems addressed by this TMDL. The thermal loadings from non-point sources enter the main stems primarily through tributaries and irrigation return flows. There are 193 tributaries including seven significant irrigation flows addressed in this TMDL.

1.2 Legal Authority

Under authority of the Clean Water Act, 33 U.S.C. § 1251 et seq., as amended by the Water Quality Act of 1987, P.L. 100-4, the U.S. Environmental Protection Agency is establishing a Total Maximum Daily Load (TMDL) for temperature in the main stems of the Columbia River from the Canadian Border to the Pacific Ocean and the Snake River from its confluence with the Salmon River to its confluence with the Columbia River. EPA is establishing the TMDL for waters within the states of Washington and Oregon and waters within the reservations of the Confederated Tribes of the Colville Reservation and the Spokane Tribe of Indians. The Idaho Department of Environmental Quality is simultaneously issuing the TMDL for waters within the jurisdiction of the State of Idaho.

The States of Oregon, Washington and Idaho worked with EPA in coordination with the thirteen tribes of the Columbia Basin to develop this inter-jurisdictional TMDL for the Columbia and Snake River main stems. The Oregon Department of Environmental Quality requested in writing (Oregon DEQ, 2001) that EPA establish the TMDL in the State of Oregon. The Department cited the interstate nature of the waterway, EPA's development of the temperature model, RBM 10, and the Department's lack of resources as the reasons for its request. The request was made pursuant to Section X of the TMDL Memorandum of Agreement between EPA and the Department of Environmental Quality dated February 1, 2000.

Idaho:

HUC	Waterbody	Boundaries	Pollutant
17060103	Snake River	Salmon River to Washington State Line [to Clearwater Confluence would be less confusing as the river is ID/WA state line]	Temperature

Oregon:

Basin	Waterbody	Boundaries	Pollutant
Lower Columbia	Columbia River	Mouth to Tenasillahe Island	Temperature
Lower Columbia	Columbia River	Tenasillahe Island to Willamette River	Temperature
Lower Columbia	Columbia River	Willamette River to Bonneville Dam	Temperature
Middle Columbia	Columbia River	Bonneville Dam to The Dalles Dam	Temperature
Middle Columbia	Columbia River	The Dalles Dam to John Day Dam	Temperature
Middle Columbia	Columbia River	John Day Dam to McNary Dam	Temperature
Middle Columbia	Columbia River	McNary Dam to Washington Border	Temperature

Middle Snake	Snake River	Washington Border to Hell's Canyon Dam	Temperature

Washington:

Water Resource Inventory Area Name	Number	**Waterbody**	**Pollutant**	**Number of Segments**
Grays-Elokoman	25	Columbia River	Temperature	3
Lewis	27	Columbia River	Temperature	2
Salmon-Washougal	28	Columbia River	Temperature	6
Klickitat	30	Columbia River	Temperature	3
Rock-Glade	31	Columbia River	Temperature	2
Moses Coulee	44	Columbia River	Temperature	1
Chelan	47	Columbia River	Temperature	1
Lower Snake	33	Snake River	Temperature	4
Snake River	35	Snake River	Temperature	4

[The tri-state MOU should be mentioned in here some place]

Similarly, the Washington Department of Ecology requested by letter (Washington DOE, 2001) that EPA establish the Columbia/Snake Main Stem Temperature TMDL in Washington. The Department also cited the inter-jurisdictional nature of the waterways, EPA's work on the TMDL and the Departments lack of resources as the reasons for its request. The request was made pursuant to Section 13 of the TMDL Memorandum of Agreement between the Department of Ecology and EPA dated October 29, 1997.

EPA has authority under section 303(d)(2) of the Clean Water Act (CWA) to approve or disapprove TMDLs submitted by the states and tribes and to establish its own TMDLs in the event that it disapproves a state or tribal submission. EPA also has authority under section 303(d)(2) to establish TMDLs in response to an explicit state request. EPA's exercise of authority to establish TMDLs in response to a state's request is consistent with the larger purpose of section 303(d)(2) – to ensure the timely establishment of TMDLs – and it honors the primary responsibility imputed by Congress to the states. In addition, when the TMDL focuses on interstate waters, EPA's involvement can facilitate the resolution of complex cross-jurisdictional problems that might be difficult for an individual state, acting alone, to resolve. For similar reasons, EPA has authority to establish TMDLs on behalf of tribes that have not been authorized to establish TMDLs under section 518(e) of the CWA.

2.0 Applicable Water Quality Standards

2.1 General

Three states and one Indian tribe have WQS standards promulgated pursuant to section 303(c) of the CWA that apply to the Columbia and Snake Rivers: Idaho, Oregon, Washington and the Confederated Tribes of the Colville Reservation. Another Indian tribe, the Spokane Tribe of Indians has WQS for the Columbia River that have been adopted by the tribe but not yet approved by EPA. The WQS for each state and tribe for the portions of the Columbia and Snake Rivers subject to this TMDL are summarized below:

2.2 Idaho

The WQS for Idaho are established in the Idaho Administrative Code, IDAPA 16.01.02, "Water Quality Standards and Wastewater Treatment Requirements." Section 130.02 establishes the designated aquatic life uses of the Snake River between the Salmon River and the Washington Border as cold water. Section 100.01.a defines cold water as "water quality appropriate for the protection and maintenance of a viable aquatic life community for cold water species." Section 250.02.b establishes the water quality criteria for temperature for the cold water aquatic life use designation as "Water temperature of twenty-two (22) ^{o}C or less with a maximum daily average of no greater than nineteen (19) ^{o}C."

Section 070.06 discusses natural background conditions: "Where natural background conditions from natural surface or groundwater sources exceed any applicable water quality criteria as determined by the Department, that background level shall become the applicable site-specific water quality criteria. Natural background means any physical, chemical, biological, or radiological condition existing in a water body due only to non-human sources. Natural background shall be established according to protocols established or approved by the Department consistent with 40 CFR 131.11. The Department may require additional or continuing monitoring of natural conditions."

2.3 Oregon

The WQS for Oregon are established in the Oregon Administrative Rules, OAR 340-041-0001 to OAR 340-041-00975, "State-Wide Water Quality Management Plan; Beneficial Uses, Policies, Standards, and Treatment Criteria for Oregon." The Snake River in Oregon from the OR/WA Border at river mile 176 to the Salmon River at river mile 188 is included in this TMDL. The WQS for that portion of the river are included in the section for the Grande Ronde Basin (OAR 340-041-0722). The beneficial uses most sensitive to temperature in that reach are "Salmonid Fish Rearing" and "Salmonid Fish Spawning." The temperature criteria applicable to the reach are, in relevant part:

> "To accomplish the goals identified in OAR 340-041-0120(11), unless specifically allowed under a Department-approved surface water temperature management plan as required under OAR 340-41-026(3)(a)(D), no measurable surface water temperature increase resulting from anthropogenic activities is allowed:
> (i) In a basin for which salmonid rearing is a designated beneficial use, and in which surface water temperatures exceed 64.0 ^{o}F (17.8 ^{o}C);
> (ii) In waters and periods of the year determined by the Department to support native salmonid spawning, egg incubation, and fry emergence from the egg and from the gravels in a basin which exceeds 55 ^{o}F (12.8 ^{o}C)....
> (vi) In stream segments containing federally list Threatened and Endangered species if the increase would impair the biological integrity of the Threatened and Endangered population;" (OAR 340-041-0725 (2)(b)(A).

The period of the year designated by the Oregon Department of Environmental Quality for the protection of salmonid spawning, egg incubation, and fry emergence in the Snake River is October 1 through June 30 (Oregon DEQ, 1998).

The numeric temperature criteria are established for the seven-day moving average of the daily maximum temperatures. If there is insufficient data to establish a seven-day average of maximum temperatures, the numeric criterion is applied as an instantaneous maximum (OAR 340-041-0006 (54)). A measurable surface water increase is defined as 0.25 ^{o}F (OAR 340-041-0006 (55)) . Anthropogenic is defined to mean that which results from human activity (OAR 340-041-0006 (56)).

The segment of the Columbia River which serves as the OR/WA border is included in this TMDL and subject to OR WQS. It stretches from the mouth of the river to river mile 309. The temperature sensitive beneficial uses vary from segment to segment along that reach as shown in Table 2-1.

Table 2-1: Oregon designated uses along the Columbia River

Basin/Columbia River Miles	**Anadromous Fish Passage**	**Salmonid Fish Rearing**	**Salmonid Fish Spawning**	**Shad and Sturgeon Spawning/Rearing**
Lower Columbia / 0-86	X	X	X	
Willamette / 86-120	X	X	X	
Sandy / 120-147	X	X		
Hood / 147-203	X	X	X	X
Deschutes /203-218	X	X		
John Day / 218-247	X	X	X	
Umatilla / 247309	X	Trout	Trout	

The temperature criterion applicable to the Columbia River in Oregon is in relevant part:

"To accomplish the goals identified in OAR 340-041-0120(11), unless specifically allowed under a Department-approved surface water temperature management plan as required under OAR 340-41-026(3)(a)(D), no measurable surface water temperature increase resulting from anthropogenic activities is allowed: ...

(ii) In the Columbia River or its associated sloughs and channels from the mouth to river mile 309 when surface water temperatures exceed 68.0 °F (20.0 °C)" (OAR 340-041-0205(2)(b)(A).

2.4 Washington

The WQS for Washington are established in the Washington Administrative Code, Chapter 173-201A WAC, "Water Quality Standards for Surface Waters of the State of Washington." Waters of the state are categorized in the Water Quality Standards into classes based on the character of the uses of each water body. The designated uses of the Columbia and Snake rivers most sensitive to temperature are salmonid migration, rearing, spawning and harvesting; and other fish migration, rearing, spawning and harvesting (WAC 173-201A-030). The most protected class on the Columbia and Snake rivers is "AA" or 'extraordinary' and this applies only to Lake Roosevelt. The rest of the river is grouped into class "A" or 'excellent' (WAC 173-201A-130). Under each of these classes, the temperature standard is applicable at any time of day or night. It applies toward fish protection in all portions of the rivers, including fish passage facilities and fish ladders within the dam structures.

Each class of water is assigned a daily maximum numeric temperature criterion. For class “AA” waters it is 16 EC and for class “A” waters it is 18 EC (WAC 173-201A-030). However, for the Columbia River below Priest Rapids dam and for the entire Snake River, a special condition applies which is two degrees higher, 20 ^oC (WAC 173-201A-130).

The Washington standards also include narrative requirements associated with natural conditions. “Natural Conditions” for temperature means water temperatures as they are best assessed to have existed before any human-caused pollution or alterations. If the Snake or Columbia Rivers are found to have a natural condition higher than the criterion, no additional temperature pollution can be added that will result in raising that natural temperature more than 0.3 ^oC. The wording of this portion of the standard indicates that the 0.3 ^oC increment is a constraint on the cumulative impact of all dischargers (WAC 173-201A-020).

There are also constraints on incremental temperature increases when existing temperatures are below the numeric criterion In some segments these allowable increases are expressed as formulas to be applied to individual sources, while in others the allowable increases are expressed as a maximum value not to be exceeded by cumulative impacts. The numeric temperature criteria and narratives establishing the allowable incremental temperature increases, applicable to the Snake and Columbia Rivers in Washington, are summarized in Table 2-2.

Table 2-2: **Washington Water Quality Standards along the Columbia and Snake Rivers**

Water Body	***Criteria***
Columbia Main Stem from the coast to the Oregon/Washington Border	"Temperature shall not exceed 20 ºC (68 F) due to human activities. When natural conditions exceed 20 ºC (68 F) no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3 ºC (0.5 F) nor shall such temperature increases, at any time exceed 0.3 ºC (0.5 F) due to a single source or 1.1 ºC (2.0 F) due to all such activities combined." WAC 173-201A-130(20)
Columbia Main Stem Priest Rapids Dam to OR/WA Border	"Temperature shall not exceed 20 ºC (68 F) due to human activities. When natural conditions exceed 20 ºC (68 F) no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3 ºC (0.5 F) nor shall such temperature increases, at any time exceed T=34/(T+9)." WAC 173-201A-130(21)
Columbia Main Stem Priest Rapids to Grand Coulee	"Temperature shall not exceed 18 ºC (64.4 F) due to human activities. When natural conditions exceed 18 ºC (64.4 F) no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3 ºC (0.5 F). Incremental temperature increases resulting from point source activities shall not, at any time, exceed t=28/(T+7). Incremental increases resulting from nonpoint source activities shall not exceed 2.8 ºC (5.4 F)." WAC 173-201A-130(21) and WAC 173-201A-030(2)
Columbia Main Stem Above Grand Coulee	"Temperature shall not exceed 16 ºC (60.8 F) due to human activities. When natural conditions exceed 16 ºC (60.8 F) no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3 ºC (0.5 F). Incremental temperature increases resulting from point source activities shall not, at any time, exceed t=23/(T+5). Incremental increases resulting from nonpoint source activities shall not exceed 2.8 ºC (5.4 F)." WAC 173-201A-130(22) and WAC 173-201A-030(1)
Snake Main Stem from the Washington/Oregon Border to the Clearwater River.	"Temperature shall not exceed 20 ºC (68 F) due to human activities. When natural conditions exceed 20 ºC (68 F) no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3 ºC (0.5 F) nor shall such temperature increases, at any time exceed 0.3 ºC (0.5 F) due to a single source or 1.1 ºC (2.0 F) due to all such activities combined." WAC 173-201A-130(98)(b)

Snake Main Stem from the Clearwater River to the Columbia River.	"Temperature shall not exceed 20 ºC (68 F) due to human activities. When natural conditions exceed 20 ºC (68 F) no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3 ºC (0.5 F) nor shall such temperature increases, at any time exceed t=34/(T+9)." WAC 173-201A-130(98)(a)

t = the maximum permissible temperature increase measured at a mixing zone boundary
T = the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.

2.5 Confederated Tribes of the Colville Reservation

The WQS for the Confederated Tribes of the Colville Reservation were promulgated by EPA at 40 CFR 131.135. These standards apply to the Columbia River from the northern boundary of the reservation downstream to Wells Dam. The Columbia River is designated as "Class I (Extraordinary)" from the Northern Border of the Reservation to Chief Joseph Dam and "Class II (Excellent)" from Chief Joseph Dam to Wells Dam. The designated uses most sensitive to temperature are "Fish and shellfish: Salmonid migration, rearing, spawning and harvesting: other fish migration, rearing, spawning and harvesting." The temperature criterion for Class I waters is:

> "(D) Temperature - shall not exceed 16.0 ºC due to human activities. Temperature increases shall not, at any time, exceed t=23/(T+5).
> (1) When natural conditions exceed 16.0 ºC, no temperature increase will be allowed which will raise the receiving water by greater than 0.3 ºC.
> (2) For purposes hereof, "t" represents the permissive temperature change across the dilution zone: and "T" represents the highest existing temperature in this water classification outside of any dilution zone.
> (3) Provided that temperature increase resulting from nonpoint source activities shall not exceed 2.8 ºC, and the maximum water temperature shall not exceed 16.3 ºC."

The temperature criterion for Class II waters is:

> "Temperature - shall not exceed 18.0 ºC due to human activities. Temperature increases shall not, at any time, exceed t=28/(T+7).
> (1) When natural conditions exceed 18.0 ºC, no temperature increase will be allowed which will raise the receiving water by greater than 0.3 ºC.
> (2) For purposes hereof, "t" represents the permissive temperature change across the dilution zone: and "T" represents the highest existing temperature in this water classification outside of any dilution zone.
> (3) Provided that temperature increase resulting from nonpoint source activities shall not exceed 2.8 ºC, and the maximum water temperature shall not exceed 18.3 ºC."

2.6 The Applicable Water Quality Standards for this TMDL

The goal of this TMDL is to achieve all of the promulgated WQS for temperature in the Columbia and Snake River mainstems. Since the standards vary according to river location and jurisdiction, the development of the TMDL begins with a reach-by-reach review of overlapping state and tribal standards to determine the most stringent standard for each reach. Table 2.3 summarizes the most stringent water quality standards for the Columbia and Snake Rivers for purposes of this TMDL.

EPA believes it is reasonable to apply the most stringent temperature water quality standard for each reach because this is an interstate TMDL and the Columbia and Snake Rivers form borders between the affected states. This approach is the only way EPA has identified to ensure that all temperature water quality standards are met for the affected segments. Based on the record available to EPA at this time, EPA is concerned that developing a TMDL targeted at the less stringent temperature standards for a particular reach would not assure achievement of the more stringent standards also applicable to ~~the~~ downstream reaches, because ~~it appears that~~ temperature loadings delivered at the border by the state with the less stringent standards – i.e., the "background" loadings – would make it difficult, if not impossible, for the ~~neighboring~~ downstream state to achieve its temperature water quality standards.

Moreover, as a legal matter, EPA is authorized to consider downstream water quality standards (including those in other states),when establishing or approving a TMDL. The U.S. Supreme Court in Arkansas v. Oklahoma, __ U.S. __ (1992), held that EPA has the authority to impose NPDES permit limitations and conditions based on downstream water standards. At issue in that case was EPA's issuance of an NPDES permit to an Arkansas facility that imposed conditions derived from the downstream state's water quality standards. (The court declined to address the issue of whether the statute required consideration of downstream standards because it found that EPA's assertion of authority was reasonable.) Noting that "the statute clearly does not limit the EPA's authority to mandate such compliance," the Court held, "The regulations relied on by the EPA were a perfectly reasonable exercise of the Agency's statutory discretion. The application of state water quality standards in the interstate context is wholly consistent with the Act's broad purpose 'to restore and maintain the chemical, physical, and biological integrity of the Nation's waters.' 33 U.S.C. § 1251(a). Moreover, as noted above, § 301(b)(1)(C) expressly identifies the achievement of state water quality standards as one of the Act's central objectives. The Agency's regulations conditioning NPDES permits are a well-tailored means of achieving this goal." The regulations considered by the court, 40 C.F.R. § 122.4(d), provide, "No permit shall be issued . . . [w]hen the imposition of conditions cannot ensure compliance with the applicable water qulaity [sp] requirements of all affected States."

The principle articulated with the Supreme Court in the NPDES permitting context applies with equal force to TMDLs, which are an important tool for implementing section 301(b)(1)(C) with respect to point source discharges. Washington, Oregon and EPA, as the permitting authority in Idaho, are required to consider water quality standards in downstream segments (including those in other states) when establishing NPDES permit limitations and conditions for sources whose discharges ultimately flow to the downstream segments. See 40 C.F.R. § 122.4(d). For point sources discharging to waters flowing into the Columbia and Snake Rivers, those permit limitations need to be “consistent with” the assumptions of the TMDL for those rivers, irrespective of state boundaries. See 40 C.F.R. § 122.44(d)(1)(vii)(B). Therefore, in order to reconcile applicable permit regulations, it follows that EPA, when establishing a TMDL for upstream waters, may take into account the downstream water quality standards that would apply, under 40 C.F.R. § 122.4(d), to point source discharges covered by the TMDL. When a water forms a border, as here, each state is potentially downstream of the other for purposes of EPA’s regulations.

Table 2-3: **Summary of Water Quality Standards that Apply to the Columbia and Snake Rivers** [like in the Intro, need to specify the metric for each criterion

Columbia River Reach	**Criterion**	**Natural Temp < Criterion**	**Natural Temp > Criterion**
Canadian Border to Grand Coulee Dam	16 EC	Natural + 23/(T+5)	Natural + 0.3 EC
Grand Coulee Dam to Chief Joseph Dam	16 EC	Natural + 23/(T+5)	Natural + 0.3 EC
Chief Joseph Dam to Priest Rapids Dam	18 EC	Natural + 28/(T+7)	Natural + 0.3 EC
Priest Rapids Dam to Oregon Border	20 EC	Natural + 34/(T+9)	Natural + 0.3 EC
Oregon Border to mouth	20 EC	Natural + 1.1 EC	Natural + 0.14EC
Snake River Reach	**Criterion**	**Natural Temp < Criterion**	**Natural Temp > Criterion**
Salmon River to OR/WA Border	12.8/17.8 EC	Up to Criterion	Natural + 0.14 EC
OR/WA Border to ID/WA Border	20 EC	Natural + 1.1 EC	Natural + 0.3 EC
ID/WA Border to Mouth	20 EC	Natural + 34/(T+9)	Natural + 0.3 EC

t = the maximum permissible temperature increase measured at a mixing zone boundary

T = the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.

2.7 ~~Antidegredation~~ Antidegradation

All four jurisdictions contain an antidegredation [sp] policy in their WQS. Generally, the antidegredation policies apply to waters that are of a higher quality than the water quality criteria. In these waters the existing ~~water quality~~ uses must be protected and pollution that would ~~reduce~~ impair the existing ~~water quality~~uses is not allowed. All four jurisdictions do provide ~~exceptions to this policy~~ for changes in water quality when certain conditions ~~apply~~are met. The antidegredation policies are reprinted in Appendix C. They are important to this TMDL because much of the year, the temperature of the main stems is below the numeric criteria.

Commented [DE4]: Page: 1
The distinction between the ambient quality and the uses is an important one often overlooked. In Tier 2 waters, those meeting criteria but not designated as outstanding resource waters (Tier 3), a change in quality is permissible with justification and public review so long as the uses are still maintained.

2.8 Mixing Zones

All four jurisdictions have mixing zone provisions in their WQS. The Colville standards refer to them as dilution zones. Mixing and dilution zones are the areas in the vicinity of point source outfalls where mixing results in the dilution of the effluent with the receiving water. Water quality criteria may be exceeded in the mixing or dilution zone. All four jurisdictions have restrictions on the size and characteristics of mixing or dilution zones. The mixing zone provisions of the WQS are included in Appendix D. [These might also be described as transition zones, without which effluent would need to meet in stream criteria at the end of the pipe]

3.0 Technical Considerations

3.1 Mathematical Modeling

The WQS that apply to the Columbia River require derivation of the specific target temperatures for the TMDL based on natural temperatures in the river (see Table 2-3). Natural temperature is considered to be the water temperature that would exist in the river in the absence of any human-caused pollution or alterations. This definition applies to all human activities: those that effect the river temperature directly such as point sources of warm water or dams and impoundments; and those that effect river temperature indirectly such as development in the water shed and air pollution that results in climate change.

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Commented [DE5]: Page: 1
We don't meet this definition in our present efforts, so I'm not so sure we want to put this forth so absolutely. There are certainly many tributary sources of heat load increase we have, for very practical reasons, treated as givens in this TMDL. There is also the matter of Dworshak's releases to the Clearwater, definitely an unnatural alteration, though one that results in cooler water and so we also roll it into the background.

Commented [DE6]: Page: 1
I am not so sure as you that the CWA was intended to take on air pollution, and in particular I think it a stretch to suggest that we can deal with global warming under the authorities of the CWA.

The Columbia River was first dammed in 1938 [wasn't Rock Island built in 1933?]and the Snake River, its principle tributary was first dammed in the 19th century. Since the 19th century the number of dams in the TMDL study area has grown to 15, and the watershed has been extensively developed for forestry, agriculture, mining and domestic and industrial uses. Such human activities in the watershed of a river generally lead to altered water temperatures in the river. In addition, small river temperature increases have occurred since the mid 1900's due to global warming in at least one major river in the northwest, the Fraser River (Foreman et al.,

Commented [DE7]: Page: 1
Not sure what you consider small, but when I looked at the data you provided a while back the cumulative increase due to climate change (part global warming, part not) could account for about 50% of the observed temp increase at Bonneville since the 1930's. I wouldn't call that small, or insignificant. I am also not sure I wouldn't consider it natural.

2001). There is little temperature data available for the free flowing Columbia and Snake rivers that would reflect natural temperature prior to the advent of these human sources of thermal energy in the watershed. Therefore, it is necessary to use a mathematical model to simulate natural temperatures in order to derive the specific temperature targets for the TMDL.

RBM 10, a one dimensional, energy budget mathematical model, was developed to simulate temperature in the Columbia River (Yearsley, 2001). It simulates daily cross sectional average temperatures under conditions of gradually varied flow. Models of this type have been used to assess water temperature in the Columbia River system for a number of important environmental analyses. The Federal Water Pollution Control Administration (Yearsley, 1969) developed and applied a one-dimensional thermal energy budget model to the Columbia River as part of the Columbia River Thermal Effects Study. The Bonneville Power Administration et al. (1994) used HEC-5Q, a one dimensional water quality model, to provide the temperature assessment for the System Operation Review, and Normandeau Associates (1999) used a one-dimensional model to assess water quality conditions in the Lower Snake River for the U.S. Army Corps of Engineers. RBM 10 was used by the Corps of Engineers for the temperature assessment in the "Lower Snake River Juvenile Salmon Migration Feasibility Report and Environmental Impact Statement" (Corps, 2002).

RBM 10 requires information on the river system and weather. Necessary river system information includes topology, geometry (cross-sectional area and width), mainstem inflows and temperatures at the model boundaries, and tributary and point source flows and temperatures. In order to simulate temperature in the absence of human intervention, geometry information is needed for the original, free flowing river. Necessary weather information is cloud cover, dry bulb air temperature; wind speed, vapor pressure of the air and atmospheric pressure. A thirty year data record consisting of the needed weather and flow information was constructed for the period from 1970 through 1999. Stream geometry for the un-impounded and existing river was compiled from the Columbia River Thermal Effects Study (Yearsley, 1969), information from the Walla Walla District, U.S. Army Corps of Engineers and from NOAA navigation charts (Yearsley, 2001). Using this record, thirty years of river temperatures were simulated for both the existing impounded Columbia River and the free flowing river. To simulate the free flowing river, the dams and point sources are mathematically removed in order to approximate natural temperature conditions within the TMDL study area.

3.2 Site Potential Temperature

This simulation strategy provides the cross-sectional average temperatures that would occur in the Columbia and Snake rivers within the TMDL study area in the absence of human activity within the main stem of the river. These temperatures are referred to in the TMDL as site potential temperatures. As the name implies, they are the temperatures that could occur in the Columbia and Snake rivers within the TMDL study area if the influence of human activity in the main stems on water temperature is eliminated. But the human influence outside the TMDL study area still remains. The inputs to the model; main stem temperature and flow, tributary temperature and flow and weather are not natural conditions. [I disagree, unless you have documented human alteration of the weather. Even then I'm not so sure such a source is within the authorities of the CWA] Flows in the main stem and the tributaries have been permanently altered by the construction of dams. Weather in the basin has likely been permanently altered by climate change or global warming. [These are two different things. Climate change is natural. Global warming is human-caused. Permanently is like forever, I seriously doubt we have altered weather permanently, and climate change is always changing.] So the term site potential is used to indicate that the simulations do not recreate the water temperatures that preceded European influence in North America. The modeling effort, by removing the impacts of all human activity from within the main-stems themselves, is a reasonable approach to use to assess natural temperature conditions

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There is one exception to the use of ~~actual~~ current conditions at the boundaries of the TMDL. Dworshak Dam on the North Fork of the Clearwater River can be operated so as to discharge deep, colder water from its reservoir as a means of improving flow and temperature conditions downstream in the Snake River to aid in the recovery of endangered salmon. Though Dworshak Dam has always released colder water into the Clearwater River, it has been operated specifically to aid Salmon recovery, ~~in this manner to~~ varying degrees, since 1991. The 2000 Biological Opinion on operation of the Federal Columbia River Power System contains a Reasonable and Prudent Alternative (RPA 19) calling for the management of Dworshack [sp] discharge to attempt to maintain water temperatures at the Lower Granite Reservoir forebay dissolved gas monitoring station at or below 20 EC. Since these Dworshack releases are not standard operating procedure at Dworshack but are instead part of implementation efforts for restoring temperatures in the river they are not included in the simulations of site potential temperature. Clearwater Rivers flows and temperatures in the model have been adjusted to eliminate those additional releases from the Dworshack Dam from 1991 through 1999 that were intended for salmon and water quality recovery in the Lower Snake.

Figure 3-1 illustrates the site potential temperature and the impounded temperature during 1977 at John Day Dam as simulated by the RBM10 model. The figure illustrates the typical differences between the site potential or free flowing river and the existing impounded river. The free flowing river tends to cool faster in the fall and winter. Temperature in the free flowing river also tends to vary more in response to changes in air temperature. Water temperature is not constant throughout the year. Neither is it constant from year to year or along the length of the river. There are warm years and cool years and the water temperature ~~changes~~ generally increases as the water moves downstream. The estimates of site potential and ultimately the TMDL target temperatures have to account for that variation.

The longitudinal variability is captured by dividing the river into a series of reaches and estimating the site potential at a target site in each reach. In this TMDL, 19 reaches were designated. See Section 5.0 for a complete discussion of the establishment of Target Sites [this capitalization is odd, what is the meaning?] for the TMDL. The ~~yearly~~ year to year variability in site potential temperature was captured [?smoothed out?] by simulating 30 years of site potential temperatures and computing the mean site potential temperature for every day of the year. Figure 3-2 illustrates the variability of site potential temperatures and the mean site potential at John Day Dam as simulated by RBM10. The 30 year mean site potential temperatures for every day of the year form the basis for this TMDL and the target temperatures that the TMDL is intended to achieve are expressed as 30 year means for every day of the year (see section 5). This is a reasonable approach for developing a TMDL when the target temperatures can fluctuate. When the TMDL is successfully implemented, water temperature during specific years will be warmer or cooler than the target temperature (a 30 year mean) because of the natural variability that occurs, but the long term mean temperatures should closely approximate the target temperatures. In Figure 3-2, the black curve labeled "IMP" represents the 30 year mean temperature under the existing impounded river conditions. The difference between the white site potential curve and the back impounded curve shows the improvement in long term mean water temperature called for by the TMDL at John Day Dam.

3.3 Implications of Using Daily Cross Sectional Average Temperature Simulations

The site potential temperatures which form the basis for the target temperatures in this TMDL are based on simulations of daily cross sectional average temperature. The water quality standards of the 3 states and tribe for temperature include criteria written in terms of maximum temperature or seven day average of daily maximum temperatures. However, the standards themselves allow temperature to exceed natural (site potential) temperature only by small incremental amounts (see Table 2-3) when natural temperature themselves exceed criteria. Considering the temporal and spatial variation of temperature in the free flowing and impounded rivers, the daily cross sectional average temperature is appropriate to use in the TMDL for three reasons.

- Daily cross sectional average temperature is a ~~good representation of~~ better estimated site potential temperature.
- The daily maximum temperature can be ~~under~~less -protective in situations where diurnal fluxes in water temperature have been decreased, which has been the case due to impoundment in the lower Snake and Columbia Rivers.~~the manner in which dams effect water temperature.~~
- ~~The daily average temperature provides a slightly conservative target for the TMDL due to the manner in which dams effect water temperature.~~

[You still have the problem that a 20°C daily average T is warmer than a 20° daily maximum, unless the diurnal flux is nil. I think the only way around that here is to show by an example that a SP daily average target with the typical impounded daily flux, results is lower daily maximum than if you were to target a SP daily maximum. Then you still have to deal with the fact that the switch to SP occurs when DM SP exceeds 20°C, not when DA SP exceeds 20°C. The former and correct application of the WQS should

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result in a broader window of SP temperatures.]

Temperature is known to vary vertically and horizontally in the existing river system because the river essentially consists of a series of deep slow moving pools. There are no rapids, water falls or channel structure to promote mixing of the water, except in the immediate vicinity of the dam tailraces. Mixing occurs below the dams but is quickly lost in the subsequent pool. So cross sectional average temperature ~~may~~ are likely not ~~be representative of~~of the same as the temperature at particular locations throughout the thalweg or main water body. The un-impounded or free flowing river, on the other hand, was ~~well~~ better mixed. Some temperature variation likely occurred in very shallow areas, around rocky protuberances and in ~~static~~ back waters because such areas warm faster toward equilibrium temperatures no matter what the thalweg temperature.[Do they even have the same equilibrium T?] Also, localized cool areas likely existed where groundwater or hyporheic up-welling occurred. But mixing would have occurred within the thalweg because of the rapid flow, intermittent rapids and water falls and diverse variety of instream channel features. Thus, the simulated cross sectional average temperature of the free flowing river is a good representation of the site potential temperature ~~of the water body~~.

[I am with you up to this last sentence, which I don't think logically follows from your preceding points. The cross-section average is more tractable to model, and thus estimated with more certainty, that is for sure. I also think you can say the cross-sectional average, or the temperature in well-mixed flow, is what you'd want to monitor because it is reproducible. I'm not sure how you get from there to it is a good representation of SP. If your statements about localized cooler areas due hyporheic exchange and groundwater inflow are true, the cross-sectional average SP may in be irrelevant. I also noticed you are talking just of cross-sectional average here, focussing on the spatial component of the question. I think that is wise. But at some point I think you need to meld the use of a daily average (one concept) and a cross-sectional average (second concept) to arrive at the first bullet above.]

Water temperature can vary throughout the day with changing air temperature and solar radiation. Simulations of hourly average temperature using the RBM 10 model demonstrate that the diel variation in the free flowing or site potential river is greater than in the impounded river. In fact, the heating and cooling cycle over 24 hours, as measured by cross sectional average temperature, is diminished in the impounded river. While the site potential and impounded rivers may have the same maximum temperature, the site potential river will cool off during the night while the impounded river will stay warmer. In this scenario, the impounded river would not exceed WQS (site potential temperature plus a small increment) during the hot part of the day because it is the same temperature as the site potential but it would exceed WQS at night because it is warmer than site potential. [I'm not sure the switch to SP+, when the DM criterion is naturally exceeded takes one from the DM to looking at temps through out the day. If so, doesn't your argument suggest we should be focusing on daily minimum temperatures?] On this same day, although the maximum temperatures of the two rivers would be the same, the daily average temperature of the impounded river was warmer. If the river temperature was regulated to daily maximum temperature under this scenario it would be under-protected. It would carry a heat load during the day higher than the site potential river. The daily average temperature is a more appropriate measure to ensure that human activity does not cause the temperature to exceed site potential temperature.

It is important to note that the site potential and impounded river water temperatures do not often coincide on the same day. It is far more usual for the temperature of the two rivers to be completely distinct on a given day, especially the 30 year mean temperatures that form the basis for target temperature. The situation in which the daily maximum temperatures are equal but the daily averages are different rarely occurs. Usually the impounded river temperature is clearly higher or lower than the site potential temperature. In this case, regulating to the daily average temperature is conservative because the impounded temperature won't raise during the day to the site potential maximum. [huh? Maybe a picture or two here could save the couple thousand words it would probably take to fully explain this]

The last concern about daily averaging is the possibility that there are days in which the daily maximum site potential temperature exceeds the criteria but the daily average does not. If this were to happen we would be setting target temperatures on the basis of site potential being less than criteria instead of greater than criteria. Examination of RBM 10 simulations of hourly average temperatures indicate that if this happens at all it is normally 1 day at the beginning of the time period when criteria are exceeded and 1 day at the end. The number of days could increase if the site potential temperature repeatedly exceeded then dipped below criteria throughout the warm period but since we are using 30 year average temperatures this never happens.

Summary

- WQS have criteria based on daily maximum temperatures.
- The standards themselves allow temperature to exceed natural (site potential) temperature by small incremental amounts.
- Cross sectional average temperature is representative of maximum temperature in the thalweg of the free flowing river so it is a good measure of site potential temperature. [NO WAY. This is blatantly false.]
- Using daily maximum site potential temperature to establish target temperatures could result in ~~under-protecting~~warmer temperatures during much of the day in the impounded river.
- Using daily average SP temperature is conservative because there is so little diel fluctuation of the cross sectional average temperature in the impounded river.
- Using daily average site potential to determine if criteria are exceeded might underestimate days of exceedance by 1 day at the beginning of the warm period and one day at the end, but using the thirty year average period makes this insignificant. [I'd like to see a demonstration of this]

∃ Throughout this report, temperature simulations and references to water temperature refer to daily cross sectional average temperatures unless otherwise noted.

4.0 Current Temperature Conditions [skipped over this section]

4.1 General

Temperature conditions in the Columbia and Snake river main stems are discussed in detail in Appendix A, "Problem Assessment for the Columbia/Snake River Temperature TMDL" (Problem Assessment). The Problem Assessment uses both existing temperature data and mathematical modeling of temperature to describe the existing temperature regime of the impounded river and the site potential temperature regime of the un-impounded or free flowing river.

Both the temperature observations and the temperature simulations provide estimates of water temperature. Since there are information gaps and uncertainties associated with both the observations and the simulations, both are used to gain an understanding of the free flowing and impounded temperature regimes and the relative importance of dams, point sources and tributaries in altering the natural regime of the rivers.

There is a considerable record of temperature data from the Columbia and Snake Rivers. McKenzie and Laenen (1998) assembled temperature data from 84 stations along the two rivers within the study area of this TMDL. However, the extensive data base from along the rivers must be used with caution. Little, if any of the data were collected with the express objective of evaluating temperature in the river. Few of the sampling sites have quality assurance objectives or followed quality control plans. Temperature measured at the same time at one dam can vary quite a bit depending on whether it was measured in the fore bay, the tail race or the scroll case. In using these data it is important to compare like stations along the river (e.g. scroll case to scroll case, fore bay to fore bay) and to use long records or repetitive examples when drawing general conclusions about temperature trends.

The RBM10 temperature model was developed to augment the understanding of temperature in the river derived from analysis of the data record. There is a good deal of information available for development of the temperature model. For example there are 30 years of continuous weather, flow and water temperature data. However, there are also modeling challenges that cause uncertainty in the modeling results. For example there is little information on temperature in the free flowing river to compare with simulated temperatures. Therefore, the problem assessment relies heavily on both data analysis and modeling analysis.

The analysis in the Problem Assessment provides the following information about the natural and existing temperature regimes of the river:

∃ The temperatures of the Columbia and Snake rivers frequently exceed state and tribal numeric water quality criteria for temperature during the summer months throughout the area covered by this TMDL.

∃ The water temperatures of the rivers before construction of the dams could get quite warm, at times exceeding the 20 ºC temperature criteria of Oregon and Washington on the lower Columbia River.

∃ However, these warm temperatures were much less frequent without the dams in place. Temperature observations show that the frequency of exceedances at Bonneville Dam of 20 ºC increased from about 3% when Bonneville was the only dam on the lower river to 13% with all the dams in place.

∃ The dams appear to be a major cause of warming of the temperature regimes of the rivers. Model simulations using the existing temperatures of tributaries and holding tributary temperatures to 16 ºC revealed little difference in the frequency of excursion of 20 ºC.

∃ Global warming or climate change plays a role in warming the temperature regime of the Columbia River. The Fraser River, with no dams, shows an increasing trend in average summer time temperature of 0.012 ºC/year since 1941, 0.022 ºC/year since 1953.

∃ The average water temperatures of the free flowing river exhibited greater diurnal fluctuations than the impounded river.

∃ The free flowing river average water temperature fluctuated in response to meteorology more than the impounded river. Cooling weather patterns tended to cool the free flowing river but have little effect on the average temperature of the impounded river.

∃ The free flowing river water temperatures cooled more quickly in the late summer and fall.

∃ Alluvial flood plains scattered along the rivers moderated water temperatures, at least locally, and provided cool water refugia along the length of the rivers.

∃ The existing river can experience temperature gradients in the reservoirs in which the shallow waters are warmer.

∃ Fish ladders, which provide the only route of passage for adult salmon around the dams, can become warmer than the surrounding river water.

4.2 Relative Impact of Dams, Tributaries and Point Sources on Temperature in

the Columbia and Snake Rivers.

Point and non-point affect water temperature by directly adding warm water to the main stems. There are 106 point sources that directly discharge to the mainstems evaluated in this TMDL. Non-point sources tend to discharge to small streams and rivers in the watershed which eventually empty into the mainstems. There are 193 tributaries to the two main stems, including 7 significant irrigation return flows. Dams affect water temperature not by adding warm water to the system, but by altering the river flow, geometry and velocity upstream of the dam. This section discusses and compares the impacts from each of these kinds of heat sources.

Advected Sources of Heat - Tributaries and Point Sources

The impact of advected sources of heat such as tributaries and point sources on the cross-sectional average temperature of the main stem Columbia and Snake Rivers is determined by the ratio of advected energy from the source to the advected energy of the main stems. Mathematically, the new main stem temperature resulting from complete mixing with a tributary or point source is expressed as:

Equation 4.1:

$$T_{new} = (V_{main\ stem} * T_{main\ stem}) + (V_{source} * T_{source}) / (V_{main\ stem} + V_{source})$$

T = temperature
V = volume

The Columbia and Snake Rivers are both quite large. The 7Q10 low flow of the Columbia ranges from 45,400 CFS at Grand Coulee Dam to 93,652 below Longview, WA. The 7Q10 low flow of the lower Snake is 14,500 CFS. Both rivers can accept a large advected thermal load without measurably increasing their temperature. For example, the largest/hottest point source in the Columbia River has a maximum discharge of 117 CFS and a maximum temperature of 39 EC. When mixed with the Columbia River at its 7Q10 low flow and 20 EC, it raises the average temperature of the Columbia by 0.02 EC. The largest discharger on the Snake River has a maximum flow of 62 CFS and a maximum temperature of 34 EC. When mixed with the Snake River at a 7Q10 low flow of 14,500 cfs and 20 EC, it raises the temperature of the Snake by 0.06 EC. The point source discharges to the Columbia and Snake rivers do not measurably increase the cross-sectional average temperature of the rivers.

RBM 10 was used to further evaluate the effects of point sources on water temperature in the Columbia and Snake Rivers. Water temperature in the river was simulated with all the point sources in place and with all the point sources removed. Permit limits, or in the absence of permit limits, highest observed temperature and flow rates were used for the point sources. Actual flow and weather data from 1970 through 1999 were used for simulating the river water temperature. Figures 4-1 and 4-2 plot the increase in temperature due to the presence of all the

point sources in the river throughout the thirty year period at river mile 42 in the Columbia River. Figure 4-1 shows all the data for the thirty year period. Figure 4-2 shows the data for times during which the river water temperature exceeded the 20 EC criterion. River mile 42 was selected as an example plot because it is the location where the increase due to point sources is greatest. Recall from Table 2-3 that the water quality standard for this stretch of river is natural temperature + 1.1 EC when natural is less than 20 EC and natural + 0.14 EC when natural is above 20 EC. Note from Figure 4-1 that the increase due to point sources never approaches the 1.1 EC allowed by water quality standards when site potential is below the criterion. When site potential was above the
criterion, temperatures exceeded the 0.14 EC increase allowed by the water quality standards 3 times in 30 years (Figure 4-2). At most sites in the river, the impact of the point sources on water temperature was much less than shown here. At Wanapum, for example, the impact never exceeded 0.016 EC throughout the 30 years. The effect of point sources on water temperature is very small and, in and of themselves, the point sources do not lead to exceedances of water quality standards when averaged in with the total flow of the river.

But the discharges do cause near-field temperature plumes that can exceed temperature standards. Even when the discharge causes no measurable increase in cross-sectional average temperature, the temperature plume could be significant with respect to aquatic life habitat if left uncontrolled. The state and tribal WQS contain provisions to regulate the size and impact of these plumes. Refer to the Mixing Zone provisions of the Idaho, Oregon and Washington standards and the "dilution zone" provision of the Colville standards outlined in Appendix D.

Like the point sources, most of the tributaries have negligible effects on the cross sectional average temperature of the main stems. To illustrate this, Table 4-1 lists a number of the major tributaries to the Columbia and Snake rivers, their average flows, the average flows of the Columbia and Snake and the temperature difference between the tributary and the main stem that would be required to increase main stem temperature by 0.5 EC and 0.14 EC at those flow ratios.

Table 4-1 Effects of Specified Tributaries on Columbia and Snake River Temperature.

Tributary	Average Flow (CFS)	Columbia Average Flow (CFS)	♠T (EC) to raise Columbia Temperature	
			0.5 EC	**0.14EC**
Spokane River	7,812	~ 100,000	7.0	1.9
Okanagan River	3,145	~106,255	17.0	4.9
Yakima River	3,569	~118,400	17.0	4.8
Snake River	55,090	~118,400	1.6	0.44
Deschutes	5,839	~185,161	16.0	4.6
Willamette	34,205	~191,000	3.2	0.92
		Snake Average Flow (CFS)	**♠T (EC) to raise Snake Temperature**	
			0.5 EC	**0.14EC**
Salmon	11240	~23560	1.5	0.43
Grande Ronde	3101	~34800	6.0	1.7
Clearwater	15430	~37901	1.5	0.48

One way to evaluate and compare temperature conditions is to enumerate the number of days in a year, or the frequency, that a specified temperature is exceeded. In order to determine the importance of tributaries to the main stems' temperature regimes, the RBM10 model was used to compare the frequency with which temperature exceeds 20 EC in the main stems under existing conditions with the frequency of exceedances of 20 EC in the main stems if the tributaries never exceed 16 EC. That is, in the first simulation, actual tributary temperatures were used. In the second simulation, the tributary temperatures were not allowed to exceed 16 EC. Figures 4-3 and 4-4 illustrate the results. The effect of restraining tributaries to 16 EC is very small in the Columbia upstream of its confluence with the Snake. The combined average annual flows of advected sources in this segment are less than 10 percent of the average annual flow of the Columbia River at Grand Coulee Dam. Downstream of the Snake River (River Mile 326) there is a small effect. The Snake River was not constrained to 16 EC, but the reductions in Snake tributary temperatures, particularly, the Salmon and Clearwater rivers resulted in slightly less frequency of exceedances in the lower Columbia. On the Snake River, holding the Salmon and Clearwater rivers to 16 EC clearly effected the frequency. But the other tributaries have little effect so that at the mouth of the Snake River, the frequency of exceedances in the Snake was similar to the existing condition.

Dams as Sources of Heat

Figure 3-1 illustrates the effect that dams have on temperature in the main stem. Note that the impounded and free flowing rivers warm up at approximately the same rate in the spring.

However, the free flowing river cools off in the late summer and fall faster than the impounded river. At John Day Dam, in 1977 the impounded river temperature returned below 20 EC 14 days after the site potential river. In the early fall the free flowing river was as much as 4.9 degrees cooler in 1977. In short, dams effect water temperature in the main stem by adding two to three weeks (or more) to the length of time that temperature exceeds the numeric criterion at John Day Dam, and the temperature is as much as 5 EC warmer in the impounded river during the late summer and fall.

Figures 4-5 and 4-6 show the effect of each individual dam on water temperature of the Columbia River and the Snake River respectively. These figures reflect the difference between site potential temperature and temperature that would result if each dam were the only dam in the river. Note that the dams as a group have much more significant effects on temperature than the point sources, with Grand Coulee causing temperatures as high as six degrees over site potential. It is also important to point out that only 8 of the fifteen dams have maximum impacts of greater than 0.5 EC: Grand Coulee, Chief Joseph, Wanapum, John Day, Lower Granite, Little Goose, Lower Monumental and Ice Harbor. Also the effects of the dams are more pronounced in the late summer and fall.

4.3 Summary

The effects of the tributaries and point sources on cross sectional average water temperatures in the main stems are for the most part quite small. The exceptions are the major tributaries: Spokane River, Snake River and Willamette River on the Columbia and Salmon River and Clearwater River on the Snake. The point sources can cause temperature plumes in the near-field but they do not result in measurable increases to the cross-sectional average temperature of the main stems. The dams, however do alter the cross-sectional average temperature of the main stems. They increase the cross-sectional average temperature by as much as 5 EC at John Day Dam in the late summer and fall and they extend the period of time during which the water temperature exceeds numeric temperature criteria.

5.0 DERIVATION OF TMDL ELEMENTS [Should start on new page]

5.1 General

The target temperatures for this TMDL are the mean site potential temperatures plus the incremental increases allowed by the WQS (see Section 2). These allowable increases vary with jurisdiction, location in the river and the site potential temperature. Where jurisdictions overlap, the allowable incremental increases in this TMDL are based on the more stringent WQS. [Isn't the bottom line that the temperature limits, load capacity, all is driven by meeting Oregon's WQS in the lower Columbia? If so, then that is what we should say here instead of being so vague.] Table 2-3 lists the allowable increases over the site potential by river reach after accounting for differences between jurisdictions.

The water quality standards divide the Columbia and Snake rivers into different reaches, each with different target temperatures to meet as shown in Table 2-3. The target temperatures result from adding the allowable increases to the site potential temperature. However, whenever the allowable increase in a river reach would result in exceedance of the water quality standards downstream of that reach, the target temperature has to be adjusted down so that it does not result in exceedance of down stream water quality standards. This actually is the case all along the rivers. RBM10 simulations indicate that the reaches cannot be allocated the full incremental increase allowed by their segment-specific standards, because these increases would cause exceedances of downstream standards. The Oregon water quality standards ~~of~~ for the lowest reach on the river, along the Oregon/Washington border (see Table 2-3), limit the allowable increase in temperature in the rest of the Columbia and Snake Rivers. The allowable temperature increases of the upstream reaches shown in Table 2-3 must all be adjusted down in order the meet the water quality standards of that down stream reach. In other words the heat load allowed in all the upstream reaches is determined by the water quality standards of the lowest river reach.

5.2 Target Sites

The TMDL must allocate heat load to 950 river miles to achieve the WQS at the furthest downstream reach of the river. The extent of this pollution problem and the attempt to address it at the basin scale necessitates the selection of a number of points-of-compliance or "target sites" that span the 950 miles. Target sites are locations in the river network where the site potential temperatures are calculated and where impacts from allocations to up-gradient sources are calculated.

In selecting target site locations, one option would be to use the downstream boundary of each segment as defined in the WQS. However, the reaches identified in Table 2-3 are quite large and vary considerably in terms of the heat sources they contain. The reaches defined in the WQS vary from containing no dams to containing 5 dams. They also vary in terms of the number of point sources they contain: ranging from no point sources to 65 point sources.

Another option, and the one selected for development of this TMDL, is to establish target sites at each dam location. As discussed in Section 4.2, the fifteen dams on the rivers have the greatest effect on temperature. The dam locations have also been the primary long-term monitoring locations in the basin. Therefore, each dam defines a reach for the TMDL with the dam located at the downstream end of the reach. Downstream of Bonneville Dam, four additional target sites are established on the basis of the distribution of point sources. The target site or monitoring point for each reach is at the downstream end. For the dam reaches, the monitoring point is in the tailrace of the dam. Water in the tailraces is well mixed and temperature observations will more closely reflect cross sectional average temperature there than elsewhere. Table 5-1 lists the target sites for each reach of the TMDL.

Table 5.1: TMDL Target Sites

Target Site	River Mile
Grand Coulee Dam	Columbia - 596.6
Chief Joseph Dam	Columbia - 545.1
Wells Dam	Columbia - 515.8
Rocky Reach Dam	Columbia - 473.7
Rock Island Dam	Columbia - 453.4
Wanapum Dam	Columbia - 415.4
Priest Rapids Dam	Columbia - 397.1
McNary Dam	Columbia - 292.0
John Day Dam	Columbia - 215.6
The Dalles Dam	Columbia - 191.5
Bonneville Dam	Columbia - 146.1
River Mile 119	Columbia - 119
River Mile 63	Columbia - 63
River Mile 42	Columbia - 42
River Mile 4	Columbia - 4
Lower Granite Dam	Snake - 107.5
Little Goose Dam	Snake - 70.3
Lower Monumental Dam	Snake - 41.6
Ice harbor Dam	Snake - 9.7

Critical Reach and Target Site

Columbia River Mile 4 is the Target Site furthest downstream. It is the only target site for which the TMDL target temperature is actually the water quality standard. In all the other reaches, the temperature will have to be less than water quality standards to achieve the water quality standards at River Mile 4.

5.3 Seasonal Variation

The RBM 10 model was used to simulate 30 years of water temperature based on actual hydrological and climatological data. This data set, consisting of daily information allows for simulation of seasonal temperature variation in the river. Temperature varies seasonally along the rivers as illustrated in Figure 3.1. Note that temperature in the impounded river system exceeds the water quality criterion of 20 EC in the summer at John Day Dam. This is typical of both rivers. Generally, along their lengths they exceed water quality criteria during the summer.

The TMDL applies throughout the year and accounts for daily changes in the water quality standard [This needs some explanation. My understanding is that the WQS changes day to day only when we are in the SP > criteria time of year throughout the year.

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5.4 Critical Conditions

TMDLs must take into account critical conditions for stream flow, loading and water quality parameters (40 CFR § 130.7(c)(1)). In a TMDL, critical conditions are the conditions under which the pollutant sources can cause the water quality standards to be exceeded. If critical flow conditions can be established, the TMDL can establish one loading capacity rather than a different loading capacity for every flow in the stream. Subsequently, only one allocation of load needs to be developed for each source. If WQS are met at the critical conditions they will be met at the less than critical conditions. [Good discussion, please share with your TMDL staff.]

It is difficult to establish critical conditions of stream flow, loading and water quality parameters (temperature in this case) for this TMDL because of the manner in which dams effect temperature and the manner in which the target temperature varies throughout the year. Dams do not discharge a heated effluent to the river. They effect temperature by altering stream geometry and current velocity. Therefore, dams don't necessarily have the greatest effect on temperature at the lowest flows as they would if they discharged a heated effluent at constant discharge rate to the river. Furthermore, since the target temperature varies throughout the year, the hottest time of the year is not necessarily the most likely time that water quality standards will be exceeded. To address these issues, this TMDL establishes targets for each day of the year. The targets are based on simulations of site potential temperature using 30 years of actual hydrologic and climatologic data. By using this entire extensive record, the targets incorporate the natural variability in the system.

5.5 Loading Capacity

The loading capacity is expressed as temperature rather than as thermal load. The regulations governing TMDL development provide for the expression of TMDLs as "either mass per time, toxicity, or other appropriate measure" (40CFR130.2(h)). Temperature is an appropriate measure in this TMDL because dams play a major role in altering the temperature regime of the river but they do not discharge water bearing a thermal load to the river. Dams alter the temperature regime of the river by altering the stream geometry and current velocity upstream of the dam. Expressing the loading capacities and allocations as temperatures addresses a potential concern that dam operators could choose to alter flow in the river to achieve thermal load targets without improving temperature.

As discussed above, the critical target site for this TMDL is the lowest target site in the system, River Mile 4. The loading capacity that governs the allocations is computed at this site. It is equivalent to the daily target temperature at that site, calculated as the mean site potential temperature plus the incremental increase allowed by the water quality standards as discussed in

Section 5.1. Recall from the discussion in Section 3.2 that the site potential temperature varies quite a bit from year to year. The loading capacity varies with the site potential. To capture that variability, the loading capacity for the TMDL is the 30 year mean loading capacity for each day of the year. Figure 5-1 depicts the loading capacity for this TMDL at River Mile 4 on the Columbia River.

5.6 Wasteload and Load Allocations

Like the loading capacity, the load and wasteload allocations for each reach are expressed in terms of temperature. [The allocations are in terms of MW as I recall. Can't allocate T as it's not additive, can't say the capacity is 20°C and you get 10°C and you over there you get the other 10°C. Say what you mean and precisely describe what was done.] The RBM 10 model was used to determine the temperature increases that human activity in each river reach could cause and still achieve the target temperature or loading capacity at Columbia River Mile 4.

This Section first describes how the gross wasteload allocations and load allocations were determined for each river reach in sub-section 5.6.1. Sub-section 5.6.2 then provides details on determination of the specific wasteload allocations. Subsection 5.6.3 goes into detail on the load allocations.

[I still maintain that a delta T is most useful. A delta T ties directly into the language in the WQS when SP is > criteria. As far as a TMDL goes, a given delta T implies a load that varies with flow, so dams can't simply turn down the flow to meet their allocation. At the same time for a given flow, on any particular day, a source can't fail to meet their load and still expect to meet the delta T. The latter scenario could happen with a fixed T, if upstream cooling occurred above expectations a downstream source could claim credit for it, meeting their target T without reducing their load. On the flip side, if an upstream source was not meeting it's load reduction responsibility, a downstream source could not meet it's target T due to events beyond it's control, but it should still be able to meet it's delta T. And I think a delta T is more practical target to measure and assess compliance by, albeit marginally so, than a 30-year average T. You would still need to assess delta T on an average basis, but I believe average difference could be practically assessed in a matter of weeks or months of careful monitoring rather than years. As a conservative approach you could assume no natural longitudinal increase in T and apply delta T through the facility (e.g. above versus below a dam), it's easy to get scads of paired T data.]

5.6.1 Gross Wasteload and Load Allocations

We are proposing to allocate to point sources their existing thermal loads. [What's the status of the memo we prepared on this, last summer I think, calling for edge of mixing zone and AKART constraints?] Figure 4-2 illustrates that while the existing point sources in the river have a very small effect on temperature, they do cause the lower river temperature to increase by nearly 0.14 EC, which is the allowable increase under the OR WQS. Therefore, there is very little increase to be distributed above that which is already occurring due to the existing point sources. The RBM 10 model was used to determine the increase that could be allowed at the target sites and still comply with the OR WQS in the lower reach along the Oregon/WA Border. Thirty years of water temperature were simulated at each Target Site by RBM 10. The 30 year mean temperature and flow from those simulations and the current thermal loads from existing dischargers were used to calculate the mean increase in temperature at each target site that results from the point sources every day of the year. Figures 4-1 and 4-2 show that the point sources cause the river to approach water quality standards only when site potential temperature exceeds the water quality criteria. Table 5-2 shows the highest temperature increases at each target site caused by point sources when site potential temperatures exceed criteria. This condition was used as a baseline to quantify the additional increase in temperature (beyond the increase due to point sources) that could be allowed at each target site.

Table 5-2: Highest Increases in 30 Year Mean Temperature that Occur within Each Reach as a result of existing Point Sources **[Would be nice to have another column in this table for the cumulative delta T, to this end I'd place the lower Snake reaches not at the bottom, but between Priest Rapids and McNary. One benefit of the cumulative look at things would be to see where we come closest to bumping up against the 0.14°C increase limit. I'd like to see a companion table to this one showing the incremental and cumulative delta T for each impoundment.]**

Target Sites	Increase (EC)
Grand Coulee	.00005
Chief Joseph	.00005
Wells	.00009
Rocky Reach	.0002
Rock Island	.001
Wanapum	.00001
Priest Rapids	0.0
McNary	.027
John Day	.0005
The Dalles	.000009
Bonneville	.004
River Mile 119	.006
River Mile 63	.05
River Mile 42	.006
River Mile 4	.0002
Lower Granite	.0334
Little Goose	.00000009
Lower Monumental	.0001
Ice Harbor	.0000001

Using the 30-year record, RBM 10 was run iteratively, applying different temperature increases to the target sites. It was found that each dam site, that is the Bonnevile Target Site and each Target Site above Bonneville, could receive an increase of 0.01 EC in addition to the increase that results from the point sources upstream of that target site. Table 5-3 shows the resulting temperature increases allowed at each target site using existing point source discharges and an additional 0.01 EC at each dam site.
[What ever happened to alternative allocation schemes for the dams, such as allocations proportional to their effect, or giving some of the nearly no-effect facilities an allocation that like the point sources allows their current small effect? Did we somewhere along the line make a

command decision I missed that all the dams should get ZERO allocation.]

Table 5-3: Temperature Increases allowed within Each Reach

Target Sites	Increase (EC)
Grand Coulee	.01005
Chief Joseph	.01005
Wells	.01009
Rocky Reach	.0102
Rock Island	.011
Wanapum	.01001
Priest Rapids	.01
McNary	.037
John Day	.0105
The Dalles	.010009
Bonneville	.014
River Mile 119	.006
River Mile 63	.05
River Mile 42	.006
River Mile 4	.0002
Lower Granite	.0434
Little Goose	.01000009
Lower Monumental	.0101
Ice Harbor	.0100001

The temperature increases in Table 5-3 represent the total increase, based on the location of point sources and their existing thermal loads, that can be caused by human activity within each reach and still meet the water quality standards at Columbia River Mile 4. They represent the gross allocations (load allocation + wasteload allocation+future growth/margin of safety) for each reach.

Table 5-4 breaks those gross allocations down into Gross Wasteload Allocations (WLA), Gross Load Allocations (LA), and Margin of Safety/Future Growth. The WLAs are for existing point sources. The LAs are for dams and nonpoint sources. The TMDL reserves the 0.01 EC increase that is available at each dam site for use as a Margin of Safety or for future development. [We are seeking comments on the appropriate use of this increase. This sentence should be in the public announcement, not the document].

Table 5-4: Gross Wasteload Allocations and Load Allocations at Each Target Site

Target Site	Temperature Increase within Each Reach (E C)	Gross WLA (E C)	Gross LA (E C)	MoS or Future Growth (E C)
Grand Coulee	0.01005	0.00005	0.0	0.01
Chief Joseph	0.01005	0.00005	0.0	0.01
Wells	0.01009	0.00009	0.0	0.01
Rocky Reach	0.0102	0.0002	0.0	0.01
Rock Island	0.011	0.001	0.0	0.01
Wanapum	0.01001	0.00001	0.0	0.01
Priest Rapids	0.01	0.0	0.0	0.01
McNary	0.037	0.027	0.0	0.01
John Day	0.0105	0.005	0.0	0.01
The Dalles	0.010009	0.000009	0.0	0.01
Bonneville	0.014	0.004	0.0	0.01
River Mile 119	0.006	0.006	0.0	0.0
River Mile 63	0.05	0.05	0.0	0.0
River Mile 42	0.006	0.006	0.0	0.0
River Mile 4	0.0002	0.0002	0.0	0.0
Lower Granite	0.0434	0.0334	0.0	0.01
Little Goose	0.01000009	0.00000009	0.0	0.01
Lower Monumental	0.0101	0.0001	0.0	0.01
Ice Harbor	0.0100001	0.0000001	0.0	0.01

Effect of Gross Allocations on Dams

Under this allocation scheme, the temperature increases above site potential temperatures at each target site are effectively zero for dams. In other words, if dams eliminate their impacts on temperature, the allowable temperature increases at each target site are just sufficient to allow point sources to discharge at their existing thermal loads with an additional 0.01 EC increase within each reach. The 0.01 E C increase is too small to be meaningful to dams. This allocation of the entire allowable increase to the point sources is reasonable in light of the great disparity in the relative impact of dams and point sources on temperature and the minuscule benefit that dams would receive from decreasing the thermal input of the point sources. Relative to the improvements required at the target sites (e.g., up to 5 degrees C at John Day Dam), the benefits to the dams of reducing the thermal loads from point sources are very small. If the point sources are allowed no thermal load, the maximum improvement to water quality is 0.14 EC below

Bonneville Dam when site potential temperature is above criteria and .385 EC below Bonneville when site potential is below criteria. [Isn't the maximum improvement by eliminating point source thermal loads even less than 0.14°C since we set aside half the load capacity as a reserve?] Much of the time, there would not be a measurable improvement in water temperature by eliminating point source loads. Furthermore, the improvement in water quality still needed by the dams to achieve water quality standards would be affected very little by removing the point source loads. If the entire allowable increase in temperature were equally distributed among all the dams, each of them would be able to increase site potential temperature by 0.02 EC when site potential is greater than criteria and 0.15 EC when site potential is less than criteria.

In a graphical representation of these allocation considerations, Figures 5-2 and 5-3 illustrate the extremely small difference made by the point sources. Figure 5-2 shows the improvement in water temperature needed and Figure 5-3 shows how little of that improvement is realized if the point source thermal loading is held to zero. In Figure 5-2, the difference between the highest curve, labeled "existing" and the second curve, labeled "TMDL" represents the temperature improvement needed. In Figure 5-3, the difference between the "Existing Curve" and the curve labeled "No PT Sources" represents the temperature improvement realized by eliminating excess thermal load from the point sources. Eliminating the point source influence on temperature realizes a very small part of the temperature improvement needed and does not significantly reduce the burden of the dams in improving temperature to a meaningful extent.

Effect of Gross Allocations on Nonpoint Sources

Nonpoint sources enter the mainstems primarily through the tributaries and irrigation canals. Neither EPA nor the states possess information about specific nonpoint sources that may discharge directly to the mainstems. For this TMDL, the impacts from these sources would be expected to be minimal based on the analysis of point source and tributary impacts. In this TMDL, all tributaries are allocated their existing loads. It should be noted that this mainstem allocation does not preclude establishment of different load allocations for nonpoint sources in future TMDLs for those tributaries on the states' 303(d) lists. The basis for the tributary allocations is discussed in detail in Section 5.5.2.1. If future tributary TMDLs call for heat load reductions that lower tributary temperatures, the present mainstem target temperatures will be more readily met.

~~Target~~ Temperature Increases at Each Target Site

Table 5-4 lists the temperature increases that can occur within each river reach and still achieve the water quality standards at Columbia River Mile 4. The daily target temperature at each target site is the temperature that results when human activity in each reach adds the temperature listed in Table 5-4 to the site potential river as it flows downstream. The site potential temperature varies quite a bit from year to year due to variability in weather and flow, as well as day-to-day with seasonal changes in weather and flow. Thus t~~T~~he daily site potential target temperature varies from year to year~~with the site potential~~. To capture that inter-annual variability, the target temperatures for the TMDL are~~is~~ the mean target temperature for each day of the year based on the 30-year record. The target temperatures for each target site are expressed graphically and in tabular form in Appendix 1.

5.6.2 Individual Wasteload Allocations

The gross WLAs in Table 5-4 are allowable temperature increases at each target site allocated to point sources. Section 4.2 discussed the effects of point sources on water temperature and Figures 4-1 and 4-2 illustrated the increase in temperature that results from point sources at River Mile 42 where the impact of the point sources is greatest. [please indicate this in Table 5-2] Section 5 explained how the temperature increases resulting from point sources were calculated and Table 5-2 listed the temperatures resulting from point sources at each Target Site. Those temperatures resulting from point sources are the same ones in Table 5-4 where they are the Gross WLA at each Target Site. The individual WLAs discussed below are expressed as the heat load a particular point source. The combined point source loads within a target site reach result in the temperature increases listed in Table 5-4.

Group Allocations and Individual Allocations

The existing point sources on the Columbia and Snake rivers range in size and effect on river temperature from very small domestic waste facilities with thermal loads as low as 0.01 MW (megawatts) to larger industrial facilities with loads as high as 540 MW. As was shown in Section 3, these facilities cumulatively do not increase water temperature by more than 0.14 EC, but some of the larger facilities do have substantial thermal loads.

To provide flexibility to the managers of these facilities and to the NPDES permitting authorities, small discharge~~r~~s within each river reach are allocated a “group allocation”. That is, one load is allocated collectively to all the discharge~~r~~s in the group.

To determine which point sources should be included in the groups, we established a threshold temperature effect. In this TMDL, the maximum increase in temperature over site potential, when site potential exceeds the water quality criterion, is 0.14 EC. This value comes from the Oregon water quality standards which define a measurable temperature increase as 0.14 EC or greater. We set the temperature effect threshold for small discharge~~r~~s at 10% of this measurable increase or 0.014 EC. For the purposes of this TMDL, point sources that increase the cross sectional average water temperature by 0.014 EC or less are grouped by reach ~~placed in the~~and given group allocations. This is based on current permit parameters or where available the 95%tile reported effluent discharge rate, maximum reported effluent temperature, and 7Q10 receiving water flow; a rare of nearly worst case scenario. [If this is not right please correct, but something to this effect should be included here]

Maximum Discharge Levels

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The target temperatures for this TMDL result in having existing point sources discharge at their current thermal loads. However, the WLA loads in this TMDL are the maximum discharge levels that the point sources could receive when their NPDES permits are issued. The permit limits may be lower than the loads established here for two reasons: adherence to State/Tribal mixing zone requirements and application of State/Federal/Tribal technology requirements. When NPDES permits are renewed, the permitting authority will evaluate each facility's compliance with mixing zone requirements and technology requirements. The effluent limits in the permit may be lower than those established in this TMDL as a result of those analyses. [Was expecting this earlier in section 5.6.1]

This TMDL establishes the following narrative WLA for each individual point source. The WLA is established as the minimum thermal load of the following: (1) the max thermal loading listed in this TMDL document; (2) the thermal loading that can be achieved through compliance with state/ederal/tribal technology requirements; and (3) the thermal loading that must be maintained to achieve mixing zone requirements in the applicable WQS. This narrative approach provides flexibility and time for facility managers and permitting authorities to complete the necessary analyses to determine the final WLA. The upper bounds established in this TMDL insure that instream WQ criteria are achieved, the final permitted WLAs may~~will~~ be more~~as~~ stringent as needed to meet these additional WQS constraints~~achieve WQS~~.

Development of the Wasteload Allocations

There are 106 point sources covered by this TMDL. Tables 5-5 and 5-6 list the Point Sources by river reach on the Columbia and Snake Rivers respectively. The tables include the existing thermal loads of each point source and indicate whether the facility will be part of a group allocation or receive an individual allocation.

Table 5-5: List of Point Sources by River Reach in the Columbia River

River Reach/Facility	Permit Number	River Mile	Load (MW)	Allocation
International Border - Grand Coulee				
Avista — Kettle Falls		702.4	1.37	Group
Grand Coulee - Chief Joseph				
Grand Coulee Dam	WA-002416-3	596.6	0.91	Group
Grand Coulee	WA 0044857B	596.6	2.52	Group
City of Coulee Dam	WA-002028-1	596	1.10	Group
Chief Joseph - Wells				
Chief Joseph Dam	WA-002242-0	545.1	0.03	Group
Bridgeport STP	WA 002406 6	543.7	1.51	Group
Brewster	WA 0021008B	529.8	1.83	Group
Patteros STP	WA 0020555 9	524.1	0.41	Group
Wells - Rocky Reach				
Wells Dam	WA 005103 9	515.8	0.0037	Group
Wells Hydro Project	WA 005104 7	515	0.01	Group
Chelan STP	WA 002060 5	503.5	7.40	Group

Entiat STP	WA 005127 6	485	0.60	Group
Rocky Reach - Rock Island				
Rocky Reach Dam	WA 005079 2	474.9	0.02	Group
Tree Top	WA 005152 7	470.8	0.33	Group
Naumes Processing	WA 005181-1	470.5	10.54	Group
Columbia Cold Storage	WA 002362 1	466.3	5.99	Group
E Wenatchee Sewer District STP	WA 00 2062-1	465.7	19.13	Group
KB Alloys	WA 0002976C	458.5	1.48	Group
Specialty Chemical	WA 0002861A	456.3	15.46	Group
Alcoa Wenatchee		455.2	17.85	Group
Rock Island - Wanapum				
Rock Island	WA 005078 4	453.4	0.01	Group
Rock Island West Powerhouse	WA 005122 5	453.4	0.01	Group
Vantage STP	WA 0050474B	420.6	0.44	Group
Wanapum - Priest Rapids				
Priest Rapids - McNary				
Columbia Generating Sta	WA-002515-1	351.75	53.70	Group
Fluor Daniel Hanford, Inc	WA-0025917	347	27.90	Group
Richland STP	WA 002041 9	337.1	57.38	Group
Baker Produce	ST 9183	329.2	0.04	Group
Twin City Foods	WA 0021768B	328.3	0.04	Group
Kennewick	WA 004478 4	328	61.40	Group
Pasco	WA 0044962C	327.6	22.75	Group
Agrium Bowles Road plant	WA 000367 1	322.6	405.82	Individual
Agrium Game Farm Road plant	WA 000372 7	321	484.69	Individual
Sanvik Metals	WA 0003701B	321	0.92	Group
Boise Cascade Walulla		316	234.90	Individual
McNary to John Day				
Goldendale		216.7	39.81	Group
John Day - The Dalles				
Biggs OR		208.7904	0.24	Group
Wishram STP	WA 005129 2	200.8	0.49	Group
The Dalles - Bonneville				
Dalles/Oregon Cherry OR		189.527	7.88	Group
Northwest Aluminum OR		188.9056	8.79	Group
Cascade Fruit OR		188.2842	0.88	Group
Lyle	WA 005048 2	183.2	0.01	Group
Mosier OR		174.6134	0.13	Group
SDS Lumber	WA 0051152B	170.2	160.32	Individual
Bingen STP	WA 00 2237 3	170.2	4.03	Group
Hood River OR		168.3994	0.44	Group
Cascade Locks OR		151.0002	0.38	Group
Stevenson STP		150	1.83	Group
Bonneville - Coast				
Tanner OR		144.1648	1.11	Group
North Bonneville STP	WA0023388B	144	0.51	Group
Multnomah Falls OR		134.2224	0.19	Group
BBA Nonwovens Washougal	WA0040177B	124	0.34	Group
Exterior Wood, Inc.		123.8	0.29	Group
Washougal STP	WA0037427B	123.5	9.11	Group
Camas STP	WA0020249A	121.2	24.81	Group
Georgia Pacific		120	313.21	Individual

Toyo Tanso USA OR		118.066	0.20	Group
Gresham OR		117.4446	106.71	Group
Marine Park Water Reclamation Facility	WA0024368C	109.5	64.43	Group
Vancouver Ice & Fuel Oil	WA0039918B	106	0.01	Group
Graphic Packaging OR		105.638	31.50	Group
Northwest Packing Co.	WA0042064A	105.2	0.35	Group
Portland STP OR [why is this large source in agroup?]		105.0166	521.94	Group
Great Western Malting	WA0000019B	105	36.28	Group
Vancouver Westside STP [why is this large source in agroup?]		105	183.02	Group
Support Terminal Services	WA0000418B	104.8	0.01	Group
Clark County PUD Lower River Rd	WA0040932A	103.2	5.20	Group
Van Alco		103	25.32	Group
Salmon Creek STP		95.5	38.24	Group
Boise/St Helens OR		85.7532	219.56	Individual
Columbia River Carbonates	WA0039721B	83.5	5.90	Group
Coastal St Helens OR		82.6462	365.09	Individual
Clariant Corp	WA0000353B	76	5.89	Group
Kalama STP	WA0020320B	75	1.63	Group
Noveon Kalama, Inc	WA0000281B	74	7.45	Group
Steelscape, Inc.	WA0040851B	73.5	1.89	Group
PGE Trojan OR		72.7038	511.15	Individual
Port of Kalama		72.2	0.08	Group
Riverwood OR		70.2182	0.07	Group
Cowlitz STP	WA0037788B	68	109.03	Group
Longview Fiber		67.4	540.99	Group
Rainier OR		67.1112	2.44	Group
Cytec Industries	WA0039012C	67	3.23	Group
Houghton International	WA0038814B	67	0.01	Group
Longview Fiber [Is this different from the Longview Fiber 4 lines above?]		67.4	540.99	Individual
Weyerhauser Longview		64	398.63	Individual
Reynolds		63	58.21	Group
Stella STP	WA0039152C	56.4	0.01	Group
PGE Beaver OR		53.4404	7.03	Group
New Source OR		52.819	24.84	Group
GP Wauna OR		42.2552	301.71	Individual
Cathlamet STP		32	0.55	Group
Astoria OR		11.8066	23.38	Group
Ft. Columbia State Park		7.2	0.02	Group
Bell Buoy Crab Co.	WA0000159B	6	0.33	Group
Warrenton OR		4.9712	2.51	Group
Ilwaco STP	WA0023159B	2	3.52	Group
Jessies Ilwaco Fish Co.	WA0000361C	2	2.75	Group
Coast Guard Sta. Cape Disappointment	WA_002422-81	1	0.01	Group

Table 5-6: List of Point Sources by River Reach in the Snake River

Snake River Reach/Facilities	Permit Number	River Mile	MW	Allocation
Salmon R - Lower Granite				
Asotin STP		145	4.01573	Group
Potlatch	ID-0001163	139.3	298.7859	Individual

Clarkston STP		**138**	**6.264627**	**Group**
Lower Granite to Little Goose				
Lower Granite Dam	**WA-002211-1**	**107.5**	**0.019394**	**Group**
Little Goose - Lower Monumental				
Little Goose Dam	**WA-002210-1**	**70.3**	**0.011575**	**Group**
Lyon's Ferry	**General**	**59.1**	**1.380896**	**Group**
Lower Monumental - Ice Harbor				
Lower Monumental Dam		**44.6**	**0.003923**	**Group**
Ice Harbor - Columbia R.				
Ice Harbor Dam		**9.7**	**0.003947**	**Group**

The loads provided in Tables 5-5 and 5-6 are computed in megawatts (equation 5-1). They are based on existing permit limits or reasonable worst case discharges from the facilities. That is, if the facility has permit limits for flow and temperature in its existing permit, they were used to calculate the load. If the facility does not have limits in its current permit, available monitoring data was evaluated to establish the highest load discharged by the facility under normal operating conditions. [I added some language on this earlier where I was expecting to find it. I thought we went with the monitoring data, unless there was none, then we fell back on the permitted limits, is that not the case?]

Equation 5-1: Point Source Heat Load in Megawatts

$$H = pC_pQ(\Delta T)(1000\frac{l}{M^3})\left(\frac{1W}{1\frac{J}{}}\right.$$

H = heat load discharged in megawatts (MW)
p = density of water (1kg/l)
C_p = Specific heat of water (4182 j/kg-EC
Q = Flow rate (m^3/sec)
T = Temperature (EC)

Tables 5-5 and 5-6 indicate that 12 of the facilities on the Columbia and Snake Rivers will be given individual wasteload allocations and 93 will be included in Group allocations. Ninety three of the 106 point sources caused an increase in cross sectional average temperature of 0.014 EC or less. The 13 point sources that have individual allocations cause more than 0.014 EC increase in the daily cross sectional average temperature, but the greatest of these in the Columbia River causes a 0.02 EC increase and in the Snake River a 0.06 EC increase. Tables 5-7 and 5-8 characterize the allocations of each river reach in the Columbia River and Snake River respectively showing the number of facilities in the Group allocations, the size of the Group allocations and the number and size of individual allocations in each reach.

Table 5-7: Characterization of Wasteload Allocations in each Reach of the Columbia River

Columbia	Group Allocations		Individual Allocations		Totals	
River Reach	Number	Load (MW)	Number	Load (MW)	Number	Load (MW)
International Border - Grand Coulee	1	1.3742442	0	0	1	1.3742442
Grand Coulee - Chief Joseph	3	4.5228915	0	0	3	4.5228915
Chief Joseph - Wells	4	3.7864583	0	0	4	3.7864583
Wells - Rocky Reach	4	8.021054	0	0	4	8.021054
Rocky Reach - Rock Island	8	70.805746	0	0	8	70.805746
Rock Island - Wanapum	3	0.4529858	0	0	3	0.4529858
Wanapum - Priest Rapids	0	0	0	0	0	0
Priest Rapids - McNary	8	224.13589	3	1125.4194	11	1349.5553
McNary to John Day	1	39.812813	0	0	1	39.812813
John Day - The Dalles	2	0.7245424	0	0	2	0.7245424
The Dalles - Bonneville	9	24.360412	1	160.32272	10	184.68313
Bonneville - Coast	44	1321.3071	7	2650.333	51	3971.6401
Total	87	1699.3042	11	3936.0751	98	5635.3793

Table 5-8: Characterization of Wasteload Allocations in each Reach of the Snake River

Snake	Group Allocations		Individual Allocations		Totals	
River Reach	Number	Load (MW)	Number	Load (MW)	Number	Load (MW)
Salmon R - Lower Granite	2	10.280357	1	298.78587	3	309.06622
Lower Granite to Little Goose	1	0.0193944	0	0	1	0.0193944
Little Goose - Lower Monumental	2	1.3924709	0	0	2	1.3924709
Lower Monumental - Ice Harbor	1	0.0039229	0	0	1	0.0039229
Ice Harbor - Columbia R.	1	0.0039467	0	0	1	0.0039467
Totals	7	11.700091	1	298.78587	8	310.48596

5.6.3 Load Allocations

5.6.3.1 Nonpoint Sources

While tributaries convey both point and nonpoint pollution to the Columbia and Snake Rivers mainstems, they are treated as nonpoint sources of thermal energy in the context of this mainstem TMDL. There are 193 tributaries including seven significant irrigation return flows in the TMDL project area. Appendix 2 lists the 193 tributaries, their USGS Gauge Number, drainage area, average flow if available, whether or not they are on the 303(d) list, and whether or not they were part of the RBM 10 model. Note that thirty of the 193 tributaries are on ~~the~~ 303(d) lists. There is no flow or temperature information available for many of the tributaries, and as already described in section 4, very few of the tributaries are large enough to effect water temperature in the mainstem. For these reasons, only the largest 25 tributaries are included as inputs in the RBM 10 model.

Generally, in TMDLs, the load allocation for tributaries is either the load needed to achieve WQS in the tributary or the load needed to achieve WQS in the main stem, whichever is less. For this TMDL, the WQS for the mainstem and most of the tributaries are based on the site potential temperatures. The site potential temperatures in the main stems have been estimated using existing tributary loads. The tributary loads that would occur if the tributaries were at site potential temperatures is not available. The existing temperatures of the 30 tributaries on the 303(d) lists may be greater than their site potential temperatures, which would result in higher site potential estimates in the mainstems. But while the target temperatures of the mainstems may decrease a small amount due to future improvements in the tributaries, the temperature increase available for allocation to human activities in the mainstem will not change. That is, the gross WLA and LA will not change. Therefore, in this TMDL, the tributaries are allocated their existing loads unless a TMDL has been established for a tributary. In that case, the tributary's load allocation for this TMDL is set at the established load allocation. To date, temperature TMDLs have been established for one tributary to the Columbia and Snake river mainstems: the Umatilla River. [This is probably a better place to put the sentence I added under Effect of Gross Allocations on Nonpoint Sources]

The gross WLA s and LAs given in Table 5-4 are for excess temperature added to the mainstems by point sources, nonpoint sources and dams. Site potential temperature estimates for the main stems are based on existing tributary loads. So there is no excess temperature in the site potential estimates due to tributaries. Therefore, none of the load allocations in Table 5-4 apply to the tributaries or to non-point sources. When the tributaries are at site potential temperatures they do not cause any excess temperature in the mainstems. However, WQS for the tributaries allow small increases over site potential. When the TMDLs are completed for those tributaries, the target temperatures in the TMDLs may have to restrict those allowable increases to achieve the downstream standards in the mainstems just as upstream allowable increases are restricted in this TMDL. [If the target is really the allowable increase and not a particular temperature.] [It might be wise to look at the reserve as a contingency for this very real possibility.]

5.6.3.2 Dams

Dam structures are not required to have NPDES permits. Dams can include point sources, such as domestic waste discharges and cooling water discharges. These discharges do receive NPDES permits and are included in the WLAs in this TMDL. But the dam itself does not receive an NPDES permit to pass water through its turbines and spillway structures. So we are including the temperature allocations for dams as LAs and reserving WLAs only for those point sources that require an NPDES permit.

However, the LA for all the dams proposed in this Draft TMDL is 0.0 EC increase over site potential temperature as listed in Table 5-4 under Gross LA. The temperature increase over site potential is a difficult statistic to monitor in the field [yes but no more so than a 30-year average T] or to develop temperature improvement measures around [I think no increase in T is a clear simple target to design improvement measures around, the real difficulty lies the measures themselves]. To make the TMDL more useful in planning temperature improvement measures at the dams and monitoring, the LAs are also expressed in terms of ~~resulting~~ estimated water temperature, temperature improvement needed at each dam, and temperature difference between respective ~~T~~target ~~S~~sites. These three analyses, taken together will allow for advanced planning to mitigate the temperature impacts of dams and for short and long term monitoring of the effectiveness of improvement measures in achieving the TMDL.

Water Temperature

Water temperature resulting from achievement of the TMDL WLA and LA is actually the target temperature as explained in Section 6.5.1. Target Temperature is expressed as the thirty year mean temperature. Appendix 1 illustrates the target temperature at each target site graphically and includes the daily targets in tabular form. The graphs in Appendix 1 include the target temperature and the existing temperatures, both as thirty year means. This illustrates the long term improvement in temperature that will be achieved by implementation of the TMDL [what it illustrates is the human induced delta T, and how much greater it is than allowable to meet WQS] and will be useful in monitoring the ultimate long term effectiveness of TMDL implementation. These target temperatures will not be useful in monitoring compliance during a specific year because they are means with considerable natural temperature variation around them. There will be warm years during which the site potential temperature will be considerably higher than depicted in the graphs in Appendix 1. Dams will not be considered out of compliance because the temperature is over the 30 year mean targets during those warm years. Ultimately, however, as the TMDL is implemented the long term mean temperatures should equal the loading capacities or target temperatures depicted in Appendix 1.

[A question for the modelers is "Are you more confident in the site potential T, or in the difference between site potential and current (past 30 years) conditions?"]

Temperature Improvements Needed at Each Dam

RBM 10 was used to simulate river conditions under the scenarios that each of the current 15 dams is the only dam in the river. This illustrates the effect that each dam has on water temperature by itself. Appendix 3 displays the results graphically and in tabular form in terms of the 30 year mean difference between target temperatures and temperatures with each dam in the river alone. Figures 6-2 and 6-3 show the temperature effects of each dam on the Columbia River and the Snake River respectively. Note that the effects of the dams vary greatly, ranging from maximum effects in the range of 0.12 EC for Priest Rapids Dam to over 6.0 EC for Grand Coulee. [This is one bound on the effect of each dam and probably gives a higher result for some than looking at the other bound, which would be removing dams one at a time. The latter analysis should also be performed.]

Temperature Difference Between Successive Target Sites

RBM 10 was used to determine the difference in temperature between all the successive dams when they are all achieving their TMDL LAs. Appendix 4 displays this information graphically and in tabular form as the 30 year means. There is considerable variation in the temperature difference between dams, even in the 30 year means. However, the temperature difference can be valuable in monitoring the effectiveness of implementation measures in the short term at specific dams. Scanning through Appendix 4 reveals that temperature differences between respective target sites is significantly altered by 5 of the dams: Grand Coulee, Lower Granite, Little Goose, Lower Monumental and Ice Harbor. When Grand Coulee Dam is achieving its TMDL targets, the maximum temperature difference between the Canadian Border and the dam is about 1 EC and it occurs in the spring. Under current conditions, the maximum difference is over 6 EC and occurs in the fall. There is a similar relationship for the Snake River Dams. Under the TMDL, the maximum difference between successive target sites is generally less than 0.5 EC and occurs in the summer. Under current conditions, the maximum differences range from a 1 EC to 2 EC and occur in the fall. The short term effectiveness of implementation measures at these dams can be evaluated by comparing the temperature difference between successive target site to the curves in Appendix 4. While we would not expect exact matches because the curves in the appendix are for 30 year means, we would expect the data to emulate the patterns in the curves. That is, the relative magnitude of the differences and the timing of the curve. If the maximum exceedances are in June and less than 0.5 EC, the implementation measures are probably having considerable effectiveness. If the maximum exceedances are in October and over 1 EC, the measures are probably not effective. [Despite the noise I think such a look at things will make it evident whether progress is being made. If the delta T remains high the facility is making no progress, if the trend is downward progress is being made, if it can't be distinguished from zero we can celebrate. Because the delta T's are large, and not as subject to year-to-year variation as actual site potential T, it should be easier to see progress in delta T.]

Summary

The LA for all the dams is 0 EC above site potential. In order to facilitate advanced planning to mitigate the temperature impacts of dams and for short and long term monitoring of the effectiveness of improvement measures in achieving the TMDL three other measures of temperature have been included with the allowable increases in temperature at the fixed monitoring stations, below each dam:

∃ overall water temperature that will result from TMDL implementation;
∃ improvement needed at each dam to achieve the TMDL, and
∃ temperature differences between respective TMDL Target Sites.

The overall 30 year mean water temperature that will result at each target site represents the goal of the TMDL. [So if we chill all the tributaries maybe we can get there without any real change in the mainstem dams] It is the desired end point of long term temperature monitoring to evaluate implementation of the TMDL.

The improvement needed at each dam can serve to prioritize dams for implementation actions. It shows the magnitude of improvements needed and the time of year they are needed.

The temperature differences between respective TMDL Target Sites will allow short term, dam specific assessment of the efficacy of measures taken at each dam.

5.7 Margin of Safety

Margins of safety can be explicit or implicit. Explicit margins of safety include:

∃ setting numeric targets at more conservative levels than analytical results indicate;
∃ adding a safety factor to pollutant loading estimates;
∃ allocating a portion of the loading capacity to the margin of safety.

A small portion of the loading capacity in this TMDL can be allocated to the margin of safety as shown in Table 5-4. [Whether this is small or not is a matter of perspective. One way of looking at it is that it is 50% of the load capacity, which makes it a rather generous of a safety margin] [We are seeking comment on whether to include 0.01 EC increase at each dam site throughout the year as a margin of safety ~~of~~ or for future growth. This sentence should be in the public announcement, not the document].

Implicit margins of safety include:

∃ Conservative assumptions in derivation of temperature targets;
∃ Conservative assumptions when developing the numeric model applications.

These forms of a margin of safety pose the problem of requiring water quality to surpass the site potential. Often in environmental analysis it is better to err on the conservative side because that offers greater protection in the face of analytical errors. In this case, however, that philosophy can result in desired improvements that are not possible to attain. Because of the importance of site potential temperatures in this TMDL it is important to err as little as possible on either side. That was a major reason for using a one-dimensional rather than a two- or three-dimensional temperature model. With the data available or likely to be available in the near future, the cross sectional average temperature is more accurately simulated than the instantaneous temperatures throughout the depth and width of the water column.

Never-the-less, there has been implicit margin of safety built into the TMDL.

∃ For point sources the single load allocation does not vary with flow. It achieves water quality standards at the 7Q10 low flow, maximum discharge T, and maximum (or 95%tile) discharge rate, thereby providing a margin of safety when river flows are greater than the 7Q10, and the when effluent flow is smaller or cooler, i.e. almost all the time.
∃ As described earlier, the use of daily average target temperatures is a conservative application of the WQS that addresses the effect of dams on diel temperature fluctuation.

5.8 Future Growth

This TMDL allocates 0.01 EC temperature increase at each dam site above that increase resulting from point sources. This small increase is meaningless in the context of operating a dam, but could be used to provide for significant allocations to point sources due to future growth and development. Since the rivers are so large, 0.01 EC translates into meaningful megawatts of thermal energy. In the Columbia, the megawatts of future growth would range from 53 MW at Grand Coulee to 100 MW at Bonneville. On the Snake River it would be about 17 MW per reach. For comparison purposes, the Richland, WA sewage treat plant discharges 57 MW. [As stated earlier MW is not a real heat load number, MWHours or MWDays would be.]

[Trouble with thinking of heat loads is that heat energy comes with a flow, so it is not possible to increase the receiving water load without increasing the load capacity. It is possible to add a heat load without changing the temperature (or even add heat load while **decreasing** the receiving water T). This is not going to be a problem with a large river like the Columbia, but it is very much an issue with smaller streams. It also means that a given heat load that just meets an allowable increase at summer threshold T, will cause a much greater increase in receiving water T at low winter receiving water temperatures.]

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6.0 Summary of the TMDL, WLAs and LAs

Table 6.1 summarizes the TMDL, the WLAs and the LAs for each river reach. The load availiable for allocation, as well as the gross WLA and the gross LA are presented in bold for each river reach. The Group WLA, the individual WLAs and the individual LA follow the gross allocations for each reach. The Group and individual WLAs are given as megawatts. The LAs are given as the temperature increase in EC that the facility is allowed.

[As I now think about it an allowable heat load makes most sense for non-point sources which can add their heat without flow, while a delta T makes most sense for point sources that can't help but add flow as well as heat load and can therefore conceivably add load to a receiving water without increasing its T.]

Some suggestions on the figures:

Use a color other than yellow in figures, it is too hard to see.

When TMDL Target Temperatures are referenced be sure to state they are 30-year averages

In figure 6-2 are these the effect downstream at RM 42, where the effects are limiting, or at the compliance point immediately below each dam? Is this the increase above Loading Capacity (SP+) or is simply increase above site potential? Not that you could see the difference in the figures, but the caption should be accurate.

Figure 6 –3, same question re: Loading capacity as above.

Any thoughts as to why the differences shown in the lower Snake are noisier than those in the Columbia? Would be interesting compare figures 6-2 & 3 to similar plots of the current delta T through each reach based on measured data. I'd try a multi day smooth on these plots, at least 7 days and maybe as much as thirty days, something that corresponds roughly to how many days of data you'd want to have to make an assessment of progress. Do you know what the spread is in these deltas across the thirty years, i.e. is Grand Coulee's peak effect more like 6°C ± 0.3°C or more like 6°C ± 3.0°C?.

Table 6-1: Summary of the Columbia/Snake River TMDL, showing gross allocations for each river reach and individual wasteload or load allocation for each facility in every reach.

River Reach / Facility	Temperature Increase Allowed Within Each Reach	Wasteload Allocation	Load Allocation	MoS or Future Growth
International Border to Grand Coulee	.01005 EC	0.00005 EC	0.0 EC	.01 EC
Group		1.37 MW		
Grand Coulee Dam			0.0 EC	
Grand Coulee to Chief Joseph	.01005 EC	0.00005 EC	0.0 EC	.01 EC
Group		5.52 MW		
Chief Joseph Dam			0.0 EC	
Chief Joseph to Wells	.01009 EC	0.00009 EC	0.0 EC	.01 EC
Group		3.79 MW		
Wells Dam			0.0 EC	
Wells to Rocky Reach	.0102 EC EC	0.0002 EC	0.0 EC	.01 EC
Group		8.02 MW		
Rocky Reach Dam			0.0 EC	
Rocky Reach to Rock Island	0.011 EC	0.001 EC	0.0 EC	.01 EC
Group		70.81 MW		
Rock Island Dam			0.0 EC	
Rock Island to Wanapum	.01001 EC	0.00001 EC	0.0 EC	.01 EC
Group		0.45 MW		
Wanapum Dam			0.0 EC	

Wanapum to Priest Rapids	**.01 EC**	**0.0 EC**	**0.0 EC**	**.01 EC**
Priest Rapids Dam			**0.0 EC**	
Priest Rapids to McNary	**.037 EC**	**0.027 EC**	**0.0 EC**	**.01 EC**
Group		**224.14 MW**		
Agrium Bowles Road		**405.82 MW**		
Agrium Game Farm Road		**484.69 MW**		
Boise Cascade Walulla		**234.90 MW**		
McNary Dam			**0.0 EC**	
McNary to John Day	**.0105 EC**	**0.0005 EC**	**0.0 EC**	**.01 EC**
Group		**39.81 MW**		
John Day Dam			**0.0 EC**	
John Day to The Dalles	**.010009 EC**	**0.000009 EC**	**0.0 EC**	**.01 EC**
Group		**0.72 MW**		
The Dalles Dam			**0.0 EC**	
The Dalles to Bonneville	**.014 EC**	**0.004 EC**	**0.0 EC**	**.01 EC**
Group		**24.36 MW**		
SDS Lumber		**160.32**		
Bonneville Dam			**0.0 EC**	
Bonneville to River Mile 119	**.006 EC**	**.006EC**	**0.0 EC**	**0.0 EC**
Group		**36.36213 MW**		
Georgia Pacific		**313.21 MW**		

River Mile 119 to River Mile 63	**0.05 EC**	**.05 EC**	**0.0 EC**	**0.0 EC**
Group		**1219.995 MW**		
Boise/ St.Helens		**219.56 MW**		
Coastal St. Helens		**365.09 MW**		
PGE Trojan		**511.15 MW**		
Longview Fiber		**540.99 MW**		
Weyerhouser Longview		**398.63 MW**		
River Mile 63 to River Mile 42	**0.006 EC**	**0.006 EC**	**0.0 EC**	**0.0 EC**
Group		**31.881 MW**		
GP Wauna		**301.71 MW**		
River Mile 42 to River Mile 0	**0.0002 EC**	**0.0002 EC**	**0.0 EC**	**0.0 EC**
Group		**32.569 MW**		
Salmon River to Lower Granite	**0.0434 E**	**0.0334 EC**	**0.0 EC**	**0.01 EC**
Group		**10.28 MW**		
Potlatch		**298.76 MW**		
Lower Granite Dam			**0.0** EC	
Lower Granite to Little Goose	**0.01000009 EC**	**0.00000009 EC**	**0.00 EC**	**0.01 EC**
Little Goose Dam			**0.0** EC	
Little Goose to Lower Monumental	**0.0101 EC**	**0.0001 EC**	**0.0 EC**	**0.01 EC**
Group		**1.38 MW**		
Lower Monumental Dam			**0.0** EC	

Lower Monumental to Ice Harbor	**0.0100001 EC**	**0.0000001 EC**	**0.0 EC**	**0.01 EC**
Ice Harbor Dam			**0.0** E**C**	

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